EDISON ELECTRIC CO.

SCIENTIFIC AMERICAN SUPPLEMENT, No. 1747

Entered at the Post Office of New York, N. Y., as Second Class Matter.
Copyright, 1909, by Munn & Co.

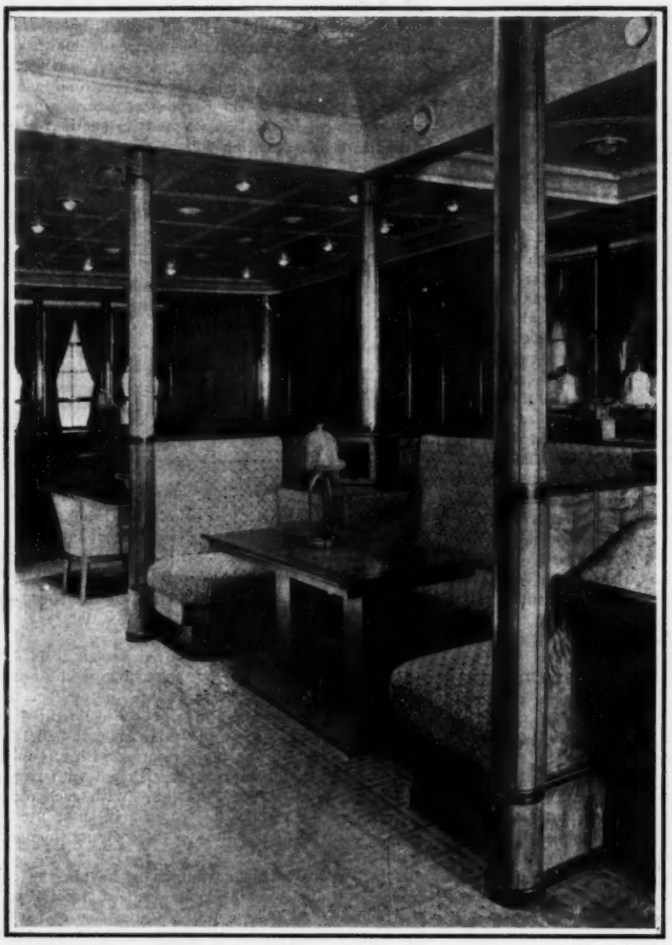
Published weekly by Munn & Co. at 361 Broadway, New York.

Charles Allen Munn, President, 361 Broadway, New York.
Frederick Converse Beach, Sec'y and Treas., 361 Broadway, New York.

Scientific American, established 1845.
Scientific American Supplement, Vol. LXVII., No. 1747.

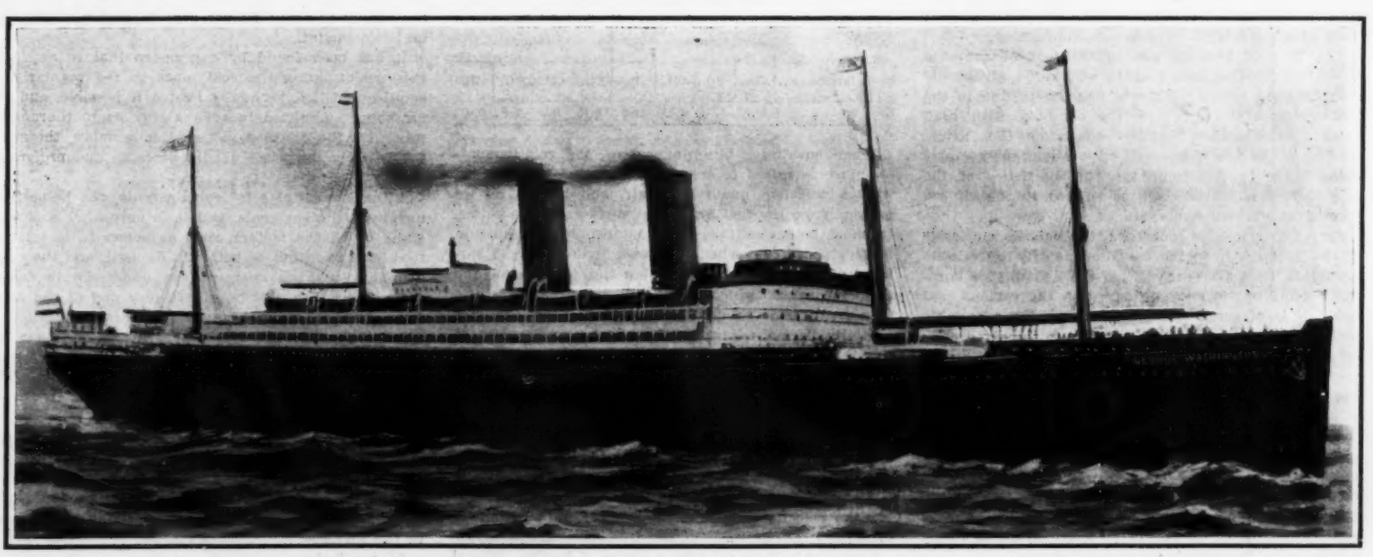
NEW YORK. JUNE 26, 1909.

Scientific American Supplement, $5 a year.
Scientific American and Supplement, $7 a year.



A CORNER OF THE SMOKING ROOM.

THE DINING ROOM.



THE NEW NORTH GERMAN LLOYD STEAMER "GEORGE WASHINGTON."—[SEE PAGE 408.]

SMOKE PREVENTION.*

THE RELATION OF THE CHARACTER OF COALS TO THE PREVENTION OF SMOKE.

BY D. T. RANDALL OF THE U. S. GEOLOGICAL SURVEY.

THE semi-bituminous and bituminous coals are the most extensively used of all the fuels which are available for generating steam. Containing as they do a considerable quantity of volatile matter, which is given off when the coals are heated in the furnace, it is difficult to burn them under boilers so as to secure perfect combustion and freedom from smoke. Specially designed furnaces and careful operation are required to get good results.

The difference in the character of coals is only partly shown by the proximate analyses which are commonly used, but to one familiar with coals these analyses indicate in a general way the leading characteristics of the coals.

To show the difference in fuels, the following table has been prepared:

TABLE I.

Analyses of Fuels as Delivered and Used.

	Coke.	Anthracite Pea Coal.	Pocahontas Coal.	Pittsburg Coal.	Indiana Coal.
Moisture	4.67	4.75	1.12	2.46	9.62
Volatile matter.	2.83	2.90	17.24	38.74	36.14
Fixed carbon.	82.61	77.15	74.84	49.18	41.22
Ash	9.90	15.20	6.80	9.60	13.02
	100.00	100.00	100.00	100.00	100.00
Sulphur	....	0.80	0.71	1.85	4.43
B. T. U.	12,306	11,886	14,530	13,172	11,122

It will be noted that coals vary both in their composition and in their heating values (B. T. U.), and in consequence they are more or less valuable as fuel, depending on these variations.

Other things being equal, a fuel high in fixed carbon is more easily burned in a common furnace without loss of heat and without smoke than those of lower percentages. Coke and anthracite coals are examples of this class of fuels.

The percentage of moisture is not of great importance except in cases in which the coal is naturally high in moisture, or in which the coal is very wet as a result of washing or exposure to storms. Moisture in small percentages seems to aid combustion, but in larger amounts it retards the ignition of the gases and lowers the furnace temperature. It may or may not increase the smoke, depending on the character of the fuel.

The percentage of ash, and especially the character of the ash, is of importance in connection with the smoke problem. Ash which is fusible and runs down onto the grate bars may cause smoke by shutting off the flow of air through the fuel, and by increasing the poking which is necessary to keep the grates free. Coals which clinker badly require more attention from the firemen, and poking the fire is a common cause of smoke.

There is a great difference in the behavior of the same coals when burned under different furnace conditions and in different furnaces. Some grates and stokers are adapted to handle coals which are burned with great difficulty on other equipment.

The rate of burning per square foot of grate is often the deciding factor as to whether a given coal may be used or not. This is principally due to the higher temperatures which are obtained with high rates of combustion, and its effects on the fusible portion of the ash of the coal. Investigations are now being made to determine the characteristics of the ash of representative coals as related to the clinker formed at various temperatures.

So far as smoke is concerned, the volatile matter is of the greatest importance. The quantity of volatile matter is not a true measure of the difficulty of burning a coal; but to one familiar with the various coal fields, it is of great assistance in choosing a suitable coal or in designing a furnace suited to the given coal.

Investigations relating to the nature of volatile matter in representative coals have been carried on at the Government Fuel Testing Plant, at the University of Ohio, and at the University of Illinois.

The results show that the differences in the gases given off from coals may be due to the composition of the coal and to the temperatures to which the coal is subjected when placed in the furnace. The higher temperatures tend to distill the volatile matter more rapidly, and drive off the heavy hydrocarbon in forms which are difficult to burn without smoke.

* A paper presented at the Syracuse meeting of the International Association for the Prevention of Smoke, June 24th to 26th, 1909.

TABLE II.

Absolute Quantities of Smoking Products in Ten Minutes' Heating at Different Temperature.*

Coal.	Temperature, Degrees C.		Smoking Products.	
	Furnace.	Coal.	Tar, Per Cent.	C_6H_6—C.c.
3 Connellsville	600	441	4 9	61
1 Ziegler	600	440	6.8	51
3 Connellsville	700	502	11.0	145
1 Ziegler	700	545	7.8	94
16 Pocahontas	700	599	4.2	138

The above table gives some idea of the complicated relation between the temperature of the coals in the furnace and the compositions of the various gases to be burned. Investigations of this character are necessary to determine the characteristics of coals from each of the representative beds.

The combustion of coke or other fuels high in fixed carbon is comparatively simple. The greater portion of the fuel is burned on the grate; the remainder in the form of gas burns at a short distance above the bed of fuel. This may readily be observed on a fire of anthracite coal, in which there is only a small percentage of volatile matter.

In burning bituminous coals, however, the difficulties are much greater, and for the reasons given above. The volatile matter from some coals is set free more readily than from others, and with some coals the nature of the volatile matter given off is such as to make it very difficult to secure complete combustion. Smoke is an indication of incomplete combustion, and the problem of reducing the amount of smoke is important, not only from the standpoint of the smoke inspector, but also because of the losses in combustible gases such as carbon monoxide (CO) and hydrogen which escape with the smoke.

TABLE III.

Showing Relation of Smoke to CO in Flue Gases.†

Average per cent of black smoke	0.0	7.1	15.5	24.7	34.7	43.1	52.9
Average per cent CO in flue gases	0.05	0.11	0.11	0.14	0.21	0.33	0.35
Number of tests averaged	37	18	56	51	26	17	4

Experiments by several investigators have shown that whenever smoke is given off there is also a considerable quantity of carbon monoxide gas, and that as a rule this gas is accompanied by small percentages of hydrogen and hydrocarbon compounds. The losses due to these combustible gases, which are found in connection with a smoky stack, may vary between one and ten per cent of the fuel.

TABLE IV.

Showing Relation between CO in Flue Gases and Other Combustible Gases.‡

	Smoky.				Clear.			
Boiler furnace	CO_2	CO	CH_4	H_2	CO_2	CO	CH_4	H_2
Hand fired	10.95	3.10	0.70	3.23	8.15	0.0	0.0	0.0

When burning a bituminous coal, the volatile matter must be raised to a high temperature while mixed with a sufficient quantity of air, and burned on its passage from the fuel bed to the surfaces of the boiler. In most boiler settings this distance for combustion is very short, and when the gases strike the cold surfaces of the boiler shell or tubes they cool below the temperature at which they will burn rapidly, and as a result some escape unburned and others are only partially burned, as shown by the heavy deposits of soot. In properly designed furnaces the space provided for combustion is large for coals giving off high percentages of volatile combustible. Even in such furnaces the firing must be carefully done, or at times enough air cannot be supplied to the gas, and smoke results for short periods. In most plants the time required for the gases to pass from the fuel bed to the top of the stack is between 10 and 15 seconds, assuming the velocity to be reasonably uniform at different sections; then it will be seen that the gases pass from the fuel bed to a distance of say 12 feet in one second. At the end of this period there is but little opportunity for the gases to burn. This will make clear the great importance of a sufficient air supply, properly distributed, and an ample space above or back of the grates, in which the gases may thoroughly mix and burn within considerably less than one second of time.

That there is a loss due to the volatile gases escaping unburned from an ordinary furnace is shown very clearly by the results of tests made on house-heating boilers. The following table gives figures obtained on two series of tests for the purpose of determining the fuel values of several coals and briquettes* when burned in a house-heating boiler.

TABLE V.

The Relation of Volatile Matter of Smoke and Unconsumed Gases.

Number of Tests Averaged.	Volatile Matter in the Combustible.	Ash in Dry Coal.	Efficiency.	Black Smoke.	CO in Dry Flue Gases.
4	18.80	8.00	60.56	18.2	0.44
12	22.71	8.94	56.33	18.0	0.59
7	34.70	11.27	54.11	22.1	0.55
11	38.79	15.06	47.19	30.8	0.62
16	44.46	14.57	47.19	32.9	0.74

The furnace in which the results shown in Table V were obtained is best suited to coke, anthracite, or low-volatile coals, and as will be seen, is not adapted for burning bituminous coals with good efficiency, yet many furnaces having practically the same features, such as a grate surrounded by heating surface and a small combustion chamber, are used in power plants for burning high-volatile coals.

Even with furnaces of improved design it is difficult to charge the coal by hand firing and secure smokeless combustion. This is due to the fact that a comparatively large quantity of gas is liberated immediately after firing, at the same time the fuel bed has been thickened, and the air enters with more difficulty and without being well distributed with respect to the gases rising from the bed. With such a furnace the loss of combustible gases may be reduced to 5 per cent or less, depending on the coal and the operation.

It is because of the advantage in having the coal gradually heated and the gases distilled from it at a low temperature, that a mechanical means of feeding the coal to the furnace is usually more successful in the prevention of smoke.

A good furnace should permit the burning of bituminous coal in sufficient quantities without loss of escaping gases or the formation of smoke when the air supply is about 50 per cent in excess of the theoretical amount.

It has been found by experience that to approach this performance, the coal must be fed regularly in small quantities, gradually heated if possible, and the air supply admitted in such a way as to thoroughly mix with the distilled gases. Furthermore, the space for burning the gases should be large and preferably inclosed in fire brick.

A furnace suitable for certain coals may be entirely unsuited to other coals, and it is only after a careful study of all the factors, such as power to be guaranteed, size and kind of boiler to be used, and the coals available, that an engineer can undertake to design a furnace which will be satisfactory and at the same time give good economy under operating conditions.

Even after the best types of furnaces are installed it is necessary to supervise the operation of the boiler plant closely in order to secure the best results. The proper drafts, the best thickness of fire for any given coal when burned on grates at the rate required for the plant, and the best method for the removal of ash and clinkers to prevent loss of fuel into the ash pit, are all factors in securing the highest economy. Failure to attend to these important details may easily cause a loss of as much as 10 per cent in the fuel fed to the furnaces.

In conclusion:

* See paper by Porter and Ovitz in Journal of American Chemical Society, vol. xxx.

† See U. S. Geological Survey Bulletin 325, pages 101 and 167.

‡ See Manchester (England) Smoke Abatement Report.

* See United States Geological Survey Bulletin No. 366.

1. Even well-designed furnaces may be expected to give off smoke if improperly operated, or under any of the following conditions:
   (a) When a new fire is built in a cold furnace.
   (b) When an excessive amount of coal is burned on the grate, making it difficult or impossible to properly mix the air with the gases and burn them in the furnace.
   (c) When the rate of combustion is suddenly changed, due to a change in demand for steam, for the same reasons as under (b).
2. Smoke may be reduced and in most cases prevented:
   (d) By burning a fuel having a small amount of volatile matter.
   (e) By burning a bituminous coal in a specially designed furnace with more than ordinary care on the part of the fireman under the supervision of a competent engineer.

THE TYRANNY OF SCIENTIFIC DOGMA.

ANY of our readers who can spare the short time necessary will find an examination into the reasons why they hold certain articles of scientific faith useful and interesting. The result of such an inquiry can hardly fail to open the mind and broaden our views. It ought to encourage research, or at least stimulate a desire for further information. The inquirer who approaches scientific questions in this way for the first time will encounter various surprises. The principal result will be that he will discover for perhaps the first time that he is living under a tyranny of scientific dogma. If he does not believe, then he runs the risk of perdition. Examples may be cited by the dozen. Thus the value of the thermal unit was originally fixed for us by one man, Joule. The great mass of students accept 774 foot pounds as the equivalent of the amount of thermal energy expended in raising 1 pound of water 1 deg. in temperature for no other reason than that Joule said that this statement was true. We are not questioning the accuracy of the statement; whether it is wrong or right, wholly true or wholly false, has nothing whatever to do with the fact that he has been taught that Joule made experiments which gave that result. The whole attitude of mind may be summed up in these words—Joule has said so and so, therefore it must be true. This has always been the attitude of mankind. An individual obtains a reputation for possessing knowledge. Therefore what he says must be true. The fact holds good of philosophers, priests, historians, politicians—particularly politicians. Ancient literature is full of examples. The wildest flights of fancy have been accepted as absolute truth; and we find that in all ages men have lived under the tyranny of dogmatic enunciation.

Our concern is, however, not with the past, but with the present. Until quite a recent period by comparison, no one ever attempted to traverse the teaching of what was known as natural philosophy. We think that Dr. Stallo in his remarkable book, "The Concepts of Modern Physics," written some twenty-five years ago, was the first to show that much that was held to be true was simply the result of an utter confusion of thought. He was followed by Mach, and he again by Poincarré and Hertz. The drift of their writing is that we dogmatize about what we do not understand, and speak fluently about things concerning which we have formed no concepts. Examples crowd in upon us. Take, for example, "Energy." It is practically impossible to get two persons disputing about the so-called "laws" of motion to arrive at a common definition of the meaning of the word energy. Who has formed a concept, which he can put into words, of the ether? How can we think of a continuous jelly with a rigidity beside which that of high-speed tool steel is as nothing, and yet through which the planets sweep as though it had no existence? It is, indeed, all things to all men. There is general or academical science, and its faiths and heresies have little influence on the progress of mankind. It is sometimes called pure science, an inaccurate definition which appears simply to mean that it is not intended to be of any use to any living creature. But there is applied science, and the beliefs and disbeliefs of people concerning this may be of very great importance indeed. The enunciations of men accepted as authorities have before now seriously retarded progress. Things have been pronounced impossible of accomplishment, and for that reason no one ventured to try to accomplish them. We can call to mind, for example, a statement made by a very eminent scientific man to the effect that the Thames Embankment could not be lighted by electricity unless at least 40 tons of copper conductors to the mile were laid down. Long before that the world was assured that to send messages under the sea from England to the United States was impossible because of the self-induction of a submarine cable. Messages might, perhaps, be got through, but the rate must be so slow that the cable would be of no practical commercial use; and such statements were accepted as being quite true, not because the disciples knew anything about the matter, but simply because Mr. So-and-so had made them. It will be within the memory of many of our readers that Edison's name was at one time enough to disturb the operations of certain departments of the New York Stock Exchange to their foundations.

Probably the most interesting aspect of the influence of authority is to be found in the way in which we accept without the least inquiry certain statements concerning heat as absolutely true. The kinetic theory of gases is, for example, usually accepted as beyond question—at least it was until the other day. Lately all our conceptions of the nature of heat have undergone radical changes, and we even begin to wonder why we ever believed what we did believe. In point of fact we could not have helped ourselves. In the present day we are gradually coming round to regard a heavy fly-wheel as a lump of negative electricity; but we do this only because Sir Oliver Lodge says it is. If some works manager, or engineer, or member of Parliament told us this thing we would not believe it; we should probably laugh. In process of time someone else will tell the world that Sir Oliver was mistaken, and that the wheel is simply a corpuscular ether vortex, and the world's students will accept this as true, but only if the new man has as high a reputation as his predecessor. But the most remarkable examples of the tyranny of dogma are supplied by those cases in which, certain statements not being found to accord with particular facts, efforts are made to reconcile the discrepancies. As one example we may cite what has come to be regarded as Clerk-Maxwell's molecular bombardment pressure theory. To this moment students are taught that the pressure of a gas is due to the bombardment of the sides of the containing vessel by molecules. It requires no great acumen to see that the permanence of pressure in, say, a gas cylinder depends on two conditions. The first is that the molecules must be perfectly elastic; the second is that the walls of the containing vessel must be either perfectly elastic or absolutely rigid. Failing these conditions the molecules will gradually lose energy, and the pressure will in time fall to zero. This truth never appears in text-books. Sir Oliver Lodge made the experiment of keeping a gas under pressure for many months. He found that, as was indeed already known, when the original temperature conditions were restored, there had been no loss of pressure; and he has advanced the theory that the gas molecules never come into contact at all with the metal, which is always coated, so to speak, with a lining of ether, which is, of course, absolutely elastic—according to theory. Perhaps in a few years our students will be taught that Clerk-Maxwell's theory is not consistent with facts, and is therefore not even a useful working hypothesis.

No more curious example, however, of the tyranny of dogma can be cited than the various attempts which have been made to frame a theory of the steam engine. No one knows what steam is. We apply certain conventional phrases to it, but they have no definite meaning. How it is produced we do not know, and all our accepted knowledge of its properties has been supplied by one man, Regnault. No one ever dreams of referring to anyone else as an authority on such matters as pressure, temperature, volume, latent heat, and so on. The French philosopher's steam tables are accepted all over the world as indisputably correct. Our correspondent, Mr. Aspinall, is, we think, the first to raise a doubt as to the absolutely infallible character of the experiments on which Regnault based his figures. Whether our correspondent is right or wrong has nothing to do with the point for which we are contending, namely, that engineers have accepted without question Regnault's figures as being accurate simply because they perceive that it would be rank heresy to doubt; and yet their unqualified acceptance has, beyond question, placed us all in a sea of difficulties. If Regnault is right then steam in an engine ought to behave in one way. It insists on behaving in a different way. If, for example, we compare the theoretical density of steam with the very carefully conducted experiments of Fairbairn and Tate, cited by Rankine, we find discrepancies that no one has succeeded in explaining away. Thus, to give two sets of figures only, for a temperature of 268 deg. F., by theory the volume of steam ought to be 635, that of water being unity. It is actually 633. The temperature being 283 deg. F., the theoretical volume is 506. The actual volume is 490. Rankine accepts as the equation for the curve of dry saturated steam expanding behind a piston in a virtually non-conducting cylinder $p\ v^{1.6}$; but it never applies in practice save by chance. It might have been imagined that in all the years which have elapsed since Watt and Trevithick gave us the steam engine an inquiry into the foundations of our faith in Regnault would have been popular. Inquiries have been made, it is true. We cannot forget Robison, Southern, Ure, Dalton, Arago, and Dulong, the Franklin Institute, and Berthelot; but when the results clashed with those of Regnault they have been rejected. Dogma has conquered.

Of course, we have not overlooked the fact that very many able men have simply ignored scientific dogma; and in numerous cases accomplished great things in consequence. This is peculiarly true of chemistry. It is not of such men we write; they stand head and shoulders above the crowd.—The Engineer (London).

PARCHMENT PAPER AND VEGETABLE PARCHMENT.

IN the manufacture of parchment papers, certain mixture proportions of water and acids, a definite temperature and duration of the mixing must not be neglected, the conversion occurring only under certain conditions. Gaines employs a mixture of 2 parts concentrated sulphuric acid and 1 part water; probably parts by volume are here indicated. According to Hofmann, the limits of dilution may be between ¼ volume and ½ volume of water to 1 volume of pure sulphuric acid. Dullo recommends 1,000 parts of sulphuric acid to 125 parts of water. If we mix 1 liter of sulphuric acid, or 1,834 grammes, with 250 cubic centimeters of water or, what is the same thing, 1,000 grammes of oil of vitriol with 136 grammes of water we obtain an acid of 1,754 specific gravity or 63 deg. Bé. In the second mixing proportion, which is described by Hofmann as just admissible, 1 liter of sulphuric acid, or 1,834 grammes, is mixed with 500 cubic centimeters of water, or what is the same thing, 1,000 grammes of oil of vitriol with 273 grammes of water; in this case, after cooling, the acid will have a specific gravity of 1.659 or 58 deg. Bé. If we take the mean between these two values, we shall have an acid of 60 deg. Bé., as made by chemical factories by evaporation in lead pans, proportionately cheaper than the concentrated acid can be applied, which probably is best to work with and enables one to avoid the exceedingly troublesome mixing of large quantities of acid with water. The temperature of the acid should not be above 60 deg. F., a somewhat lower temperature will do no harm, whereas, at a higher heat, the paper may be dissolved into a slimy mass. The period of contact between paper and acid must not be long, it must be gaged to some extent by the thickness of the paper. For thin papers, 5 seconds suffices, even the thickest do not require more than 20 seconds. Immediately after the paper has been removed from the acid, it must be put in water and washed with constantly fresh water, until it no longer shows a trace of acid. To be certain that all acid has been neutralized, the paper may be finally passed through a weakly alkaline bath and then washed again. In wholesale manufacture, as in a factory, the unsized, endless web of paper, wound as a reel, is passed through a lead-lined vessel, about a lead-covered roller, submerged in the acid. After emerging from the acid it is passed between a pair of rollers, which, by moderate pressure, express the superfluous acid, which flows back into the first receptacle. From here it is passed, in the same manner, through several vessels containing water, into the last of which a continuous supply of fresh water is pouring. To remove the last trace of free acid it is then passed through a receptacle, the water in which, by means of an addition of ammonia renewed from time to time, is kept always weakly alkaline. It is finally passed again through clean water. The more thorough the washing before it enters the alkali bath, the less ammonia will be used; it is therefore to the interest of the manufacturer to make the washing as perfect as possible, so that the ammonia bath may be a more useful than necessary precaution. After the last washing, the paper passes between a pair of felted rollers, in order to be freed as far as possible from water, then, kept tight by drying felts, between the drying cylinders, and before it is perfectly dry, through a calendering press, the rolls of which are heated by steam. During the drying, care must be taken to maintain high tension in the breadth, parchment paper wrinkling at this stage to a much greater extent than ordinary paper, and it may acquire an uneven surface, if this is not obviated by stretching. If it is desired to produce particularly thick parchment paper, two paper webs are carried separately into the acid bath, but on leaving the acid, caused to pass between the first pair of rolls, before they enter the water, they are passed together between the compression rolls. The two sheets will then adhere so closely together that they can by no means be separated.

Uranium Glass.—In the manufacture of uranium glass use is made of oxide of uranium. Window glass, as well as hollow glass, can be made in the peculiar greenish-yellow, fluorescent color of uranium glass. The iridescent glass, such as is used for making drinking vessels, requires 1½ parts of oxide of uranium to 100 parts of sand, 36 parts of potash, 14 parts air-slaked lime, 1 part saltpeter, and ½ part arsenic, whereas green *à la Pompadour*, for drinking vessels, requires only ¾ of a part of oxide of uranium to 100 parts of sand, 36 parts of potash, 13 parts of air-slaked lime, ⅝ part oxide of copper, ¾ part oxide of iron, 1/3 part oxide of manganese, and ⅛ part arsenic.

THE ANT AND HER WAYS.

A BIOLOGICAL STUDY.

BY PROF. K. ESCHERICH

FEW animals are more interesting than ants. The Bible and the works of Greek and Roman authors contain many references to them, and at the present day zoologists, physiologists, psychologists, and sociologists alike are diligently studying these social insects and seeking an explanation of the wonderful harmony and order which prevail in their great commonwealths, some of which contain millions of inhabitants. Philosophical systems have been based upon the ways of the ant, which have been adduced as evidence for or

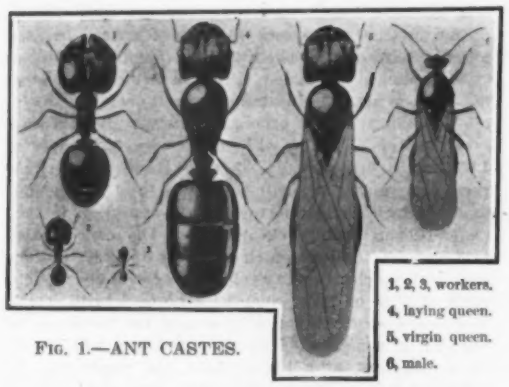


FIG. 1.—ANT CASTES.

against monism or dualism, according to the author's viewpoint. Do ants possess almost human intelligence, superior to that of most mammals, or are all their actions instinctive or reflex? If the former conjecture is true the theory of development must be false.

Let us look at a few of the most striking facts that have been discovered in recent years.

Ants are nearly related to bees and wasps, and are included with these in the order Hymenoptera. The ant family is distributed over the entire globe and comprises 170 genera and some 5,000 species and varieties. All ants form societies, also called states and colonies, but these communities vary enormously in population, habits, division of labor, etc. The number of citizens ranges from 50 or 100 to millions and probably billions and the social organization exhibits every stage of development from the most primitive to the most complex. In all cases the community comprises at least three classes or castes, males, females, and workers. The workers, which are sterile females with atrophied

FIG. 2.—AN ANT HILL (EASTERN PRUSSIA).

ovaries, build, maintain, and defend the nest, provide food, take care of the young ants and do all the work. They constitute almost the entire population, for there are only from one to sixty fertile females, or queens, and the few males leave the home nest a few days after they attain maturity. The three castes are usually very different in appearance. The males and queens are generally winged, the workers are always wingless (Fig. 1).

The workers are divided into sub-castes, assigned to various occupations and often differing conspicuously in size and form. The smallest workers clean house, feed the young brood, weed the mushroom beds, hull the grain, etc., while the large workers defend the colony, collect food, and do other heavy work. Workers with immense heads and jaws are called "soldiers," sometimes incorrectly. Others, with distended abdomens used for storing honey, are properly called "honey pots."

The most conspicuous work of the ants is their

FIG. 3.—BROOD CHAMBERS, WITH EGGS, LARVÆ, AND PUPÆ.

housebuilding. On the outskirts of coniferous forests are found conical mounds, some of them six feet high, composed chiefly of twigs, leaves, and pine needles (Fig. 2).

On warm days thousands of ants swarm in and out

FIG. 4.—PIECE OF FIR TREE RIDDLED BY ANTS OF THE SPECIES CAMPONOTUS LIGNIPERDUS.

of many orifices and cover the surface, but at night and in cold weather the exterior is deserted and even the entrances have vanished. The visible ant hill is only a part of the nest, the bottom of which is often more than a yard below the base of the hill. The subterranean part is the most important, and in many districts the leafy mound is wanting. The mound is

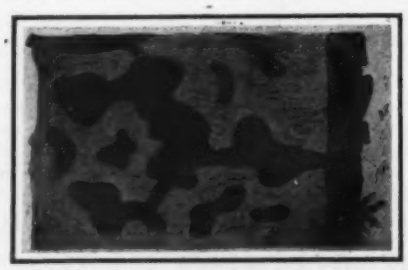


FIG. 5.—SECTION OF PEAR BRANCH EXCAVATED BY COLOBOPSIS TRUNCATA.

a, entrance stopped by a soldier ant.

chiefly a protection against cold; its interior is often 15 or 20 degrees warmer than the air outside, and the majority of the workers and the young brood are always found in the warmest part, unless that part is

FIG. 6.—FRINGE-LIKE PAPER NESTS OF AZTECA BARBIFEX.

excessively hot. As the temperatures of the various parts incessantly change with the height of the sun, and as the brood requires different conditions of temperature and humidity at different ages, the workers are ever busy in moving their charges from place to place. At one time the eggs are placed above the larvæ and pupæ, at another the order is reversed (Fig. 3). The community may occupy a single hill, or a number of connected hills. The largest ant cities include hundreds of hills and millions of inhabitants.

Only the "forest ants," of the genus *Formica*, construct leaf mounds. Most European ants erect hills of

FIG. 7.—PAPER NEST OF CREMATOGASTER. (SOUTH AFRICA.)

earth over their subterranean nests, which are sometimes connected with storehouses by long tunnels. In building, the earth is formed into pellets which are laid in rows and cemented together. This work is done with the wide, toothed mandibles which, in function, are rather hands than jaws. A few species erect no hills, but in some cases surround the entrances to their underground homes with walls of loose earth.

Still other ants are wood borers. A common European species lives in concentric annular chambers, excavated in the softer parts of the annual rings of spruce and other trees (Fig. 4). Many trees are thus riddled to a height of 30 feet. Woodpeckers prey upon these big ants, but the remedy is almost as bad as the disease.

There are smaller ants, which tunnel through hard-

wood trees in every direction. The labyrinth has very few entrances (often only one) and each entrance is always closed by the body of an ant of special type, with a blunt head, the front of which has a rough bark-like appearance (Fig. 5). This gatekeeper leaves his post only when a stroke by the feeler of a fellow citizen

FIG. 8.—NEST OF SILK AND CUT LEAVES. (JAVA.)

warns him that the latter wishes to enter or leave the nest.

The wood gnawed by the borers is simply thrown out of the nest, but there are ants which build nests of paper made of wood pulp and saliva. These nests vary greatly in size and shape, some being no bigger than walnuts and others six feet in length. They are common in the tropics, where they are usually suspended

FIG. 9.—NEST OF LEAVES CONNECTED BY SILK. (CEYLON.)

from branches (Figs. 6 and 7), but the nearly black nest of the only European paper-maker (*Lasius fuliginosus*) is generally built in a hollow tree.

Still other species weave nests of pure silk, of silk mixed with leaf fragments, or of living leaves with their edges brought together and fastened with silk (Figs. 8, 9, and 10). The silk is spun by the larvæ, which are also used as shuttles, each worker holding in her jaws a larva and applying its mouth to the leaf

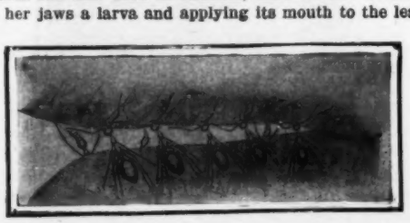


FIG. 10.—ANTS (*OECOPHYLLA*) REPAIRING A TORN LEAF NEST.

(Fig. 11). This is probably the only instance of the use of tools in the animal kingdom. The silk-weavers are confined to the tropical regions of India, Australia, Africa, and Brazil.

In most species of ants the original nest is retained as long as the community exists, unless the nest is frequently disturbed, when the colony moves to a quieter home, the workers carrying the larvæ in their jaws. The moving process is completed in a few days.

In tropical Africa and America, however, there is a sub-family of ants, the *Dorylinæ*, which have no fixed homes, but move from place to place in immense, compact hordes, devouring everything edible, even within houses, where they are welcomed as destroyers of vermin. When these wandering ants halt they assemble in hollow trees and other sheltered spots, forming

FIG. 11.—ANT (*OECOPHYLLA*) USING LARVA AS A SHUTTLE.

great clusters around their larvæ and pupæ.

The feeding habits of ants are as diversified as their house building. Some are vegetarians and others are flesh-eaters, but the former do not despise a fat caterpillar or the latter a sweet fruit. All ants love sweets. Honey placed near an ant hill is licked up greedily, until the abdomens of the insects are swollen to twice their normal girth. But these seeming gluttons have

FIG. 12.—ONE ANT FEEDING ANOTHER.

taken little of the honey for their individual use; most of it is stored in their crops to be subsequently regurgitated into the mouths of other ants or larvæ (Fig. 12). The very extensible crop is connected with the stomach by a valve which is opened only when its possessor requires food. Hence Forel calls the crop the social or communal stomach.

The crop is particularly extensible in the honey ant of Colorado (*Myrmecocystus melliger*), which feeds chiefly on the sweet juice of scrub oak galls. As this juice is produced only during a short season, it must be stored in some way, and as the ants have not learned the art of constructing water-tight cells, as bees do,

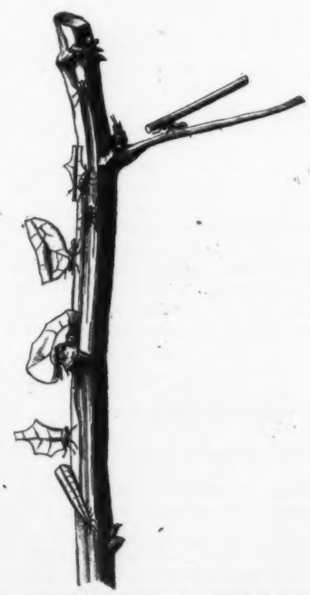


FIG. 13.—LEAF-CUTTERS (*ATTA*) DESCENDING A STALK WITH THEIR PLUNDER.

some of the workers are used as honey pots. The abdomen is distended into a great ball (Fig. 14). Thenceforth the mis-shapen insects, perfectly helpless, hang motionless from the roofs of the storerooms, and are tapped from time to time (Fig. 15). A nest may contain several hundred honey bearers. The natives collect them and express the honey, of which about a pound is obtained from 1,000 insects. Attempts to keep honey ants, as bees are kept, have failed.

A contrast to the honey ants is presented by the harvesting ants of the Mediterranean. They were known in ancient times, and Solomon commends the wisdom of their ways. The harvesters collect and store seeds, which they are able to prevent from sprouting until they require sugar produced in germination.

A far more elaborate method of obtaining food is practised by certain South American ants, which cut

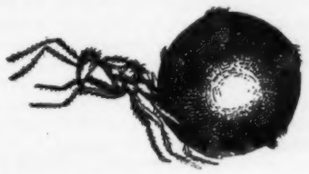


FIG. 14.—"HONEY POT" (*MYRMECOCYSTUS*).

round pieces from the leaves of trees, carry them into their nests, and convert them into a soft sponge-like mass, inclosing numerous chambers and galleries. This mass, known as the "mushroom bed," is at once the home of the perfect males and females and of the young brood and the source of food for the whole colony. The leaf pulp is permeated by a fungus, which develops numerous little white button-shaped protuberances.

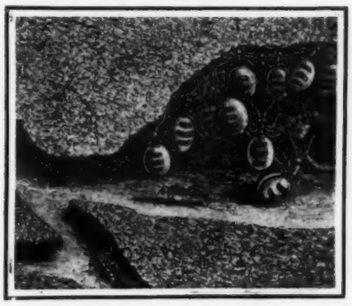


FIG. 15.—STOREROOM WITH LIVING HONEY POTS.

These serve no reproductive or vital function of the fungus, but are apparently the result of artificial cultivation by the ants, which use them exclusively as food. If the ants are removed from the mushroom bed, the white mushrooms cease to grow and their place is taken by a layer of mold. As the mushrooms or "cabbages" do not occur in nature they must be transplanted from old to new colonies. The young queen, the founder of the new colony, brings with her a little of the fungus in a special cheek pouch, plants it in the new home and continues to fertilize the growing garden by detaching fragments, voiding excrement on them, and burying them in the bed. Her children

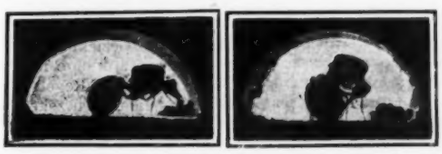


FIG. 16.—QUEEN MANURING HER MUSHROOM BED.

carry on the good work and bring fresh leaves, and so the mushroom bed grows, sometimes to a height of 3 feet and a circumference of 18 or 20 feet.

Ant communities, though apparently so exclusive, harbor various foreign inmates. Ants are strongly attracted by aphides, or plant lice. The ant strokes the aphis until the latter exudes the sweet liquid known

FIG. 17.—"MILKING THE COW."

as honey dew, which the ant swallows. The process is known as "milking," and the aphides are called the ants' "cows," but the so-called milk is simply the excrement of the aphides, which contains much sugar and other unassimilated foodstuffs. Many ants feed exclusively on honey dew, and take good care of their "cows," protecting them from enemies, and dragging them to specially erected shelters in time of danger.

In the absence of aphides other small insects are used as "cows."

A very different position with respect to the ants is occupied by their so-called "guests." These are insects, chiefly small beetles, which by various stratagems have succeeded in entering the carefully guarded ant nest. Some, like the "ant ape" (Fig. 18), imitate their hosts in appearance. Others exude narcotic secretions which affect ants as alcohol and opium affect men (Figs. 19 and 20). These guests and many others and their larvæ are carefully fed and groomed by the ants, sometimes to the neglect of the ant larvæ. Intruders of another class are tolerated because they cannot be expelled, owing to their strength or their thick, smooth armor, and the members of still another group are too small to be seen distinctly by the ants. A great variety of guests is often found in a single nest, and their objects and activities are as diversified as their shapes and sizes. Many repay their hosts' kindness by devouring the ant larvæ, others are beggars and thieves, feeding on their hosts' refuse or filching a little of the honey with which one ant is feeding another (Fig. 21).

FIG. 18.—ANT APE (*MIMECITON*).

One little beetle (*Thorictus foreli*, Fig. 22, *B*), attaches itself, for some unknown reason, so firmly to the ant's antenna that it cannot be dislodged. A little mite (*Antennophorus*, Fig. 22, *A*), clings to the under side of its host's head and with its long forelegs tickles the ant's throat until a drop of food is regurgitated. The story of ant guests is inexhaustible and full of surprises, and all these intruders cheat and rob their hosts.

The subject of slavery naturally follows the subject of guests. As a rule, all the ants of a community are of the same species and descendants of a common ancestor. Many species, however, form mixed colonies. The nests of the red robber ant (*Formica sanguinea*) contain numerous black ants of an allied species (*Formica fusca*). The two species live together in perfect harmony. All the black ants are workers, while the red include workers, females, and young. Hence the blacks are called "slaves," and the red ants "masters." The slaves, however, are driven by their inborn instincts, not by the whip.

In order to understand the origin of slavery among ants it is necessary to glance at the normal mode of founding new colonies. Ants do not swarm like bees, but each young queen, after her wedding flight, breaks off her wings and proceeds to found a new colony unaided. Thousands of queens perish in the attempt, but thousands go out annually from each community. The queen first digs a small underground chamber, entirely inclosed, in which she remains immured, without food, until her first brood has attained maturity. The young workers then open the cell, gather food, and the social life of the colony begins. The founding of a colony is a tremendous task, and many queens evade it by entering small colonies of other species, where they either become adopted or kill the natives and take possession of the worker pupæ. The mixed colony thus produced becomes a pure colony of the queen's species after the

FIG. 19.—NARCOTIC WEEVIL (*CLAVIGIO*).

native workers have died off, unless the supply of slaves is kept up by stealing pupæ from neighboring communities. This is done by a number of species, which maintain permanently mixed colonies. The slave drivers adopt various tactics in their raids, some species marching in compact armies, others in scattered detachments. The most notorious slave raider is the big red amazon ant, a born soldier, with sword-like mandibles which are murderously effective in warfare but useless for any other purpose (Fig. 23 *a*). Hence the amazons are compelled to rely on their slaves for all household labor and building, the care of the young, etc. They cannot even feed themselves.

In some species the degeneration produced by slave holding goes so far that the masters are helpless parasites on their slaves. Though these masters are all males and perfect females, the worker class being no longer produced, they are wingless grublike creatures scarcely capable of locomotion (Fig. 23*b*).

Mixed colonies, however, are comparatively rare. As

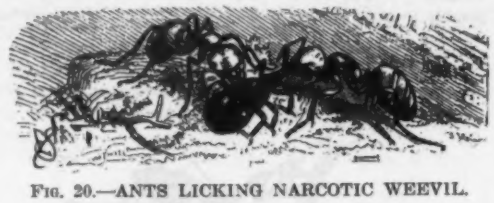


FIG. 20.—ANTS LICKING NARCOTIC WEEVIL.

a rule no outsider, even of the same species, is permitted to enter the nest. The struggle for existence is always fiercest between animals of the same species. Neighboring communities of ants are prone to engage in wars which continue during weeks and months and usually end with the annihilation of the weaker community.

All ants are more or less pugnacious and in long intervals of peace they amuse themselves with sham battles, rising upon their hinder feet and wrestling, seizing each other by the jaws, antennæ, or legs, mounting on each others' backs, and rolling over and over, etc. (Fig. 24). No injury is ever inflicted in these combats.

Some of the relations existing between ants and plants have already been mentioned, but the theme is by no means exhausted. In Europe, the injuries inflicted on vegetation by ants are confined to the operations of the wood borers and the occasional destruction of buds and fruit, but in the tropics great damage is done, especially by the leaf-cutting ants, which make the cultivation of oranges, pomegranates, and some other trees almost impossible in certain regions. On the whole, ants benefit vegetation by destroying injurious insects. A multitude of ant hills gives effective protection to a forest, for a single large colony can destroy 100,000 insects every day. The Chinese and Japanese have long utilized ants for the protection of

FIG. 21.—FILCHING HONEY ON ITS PASSAGE FROM MOUTH TO MOUTH.

gardens from insects, and the same practice might well be adopted elsewhere.

Many plants live in symbiosis, or association for mutual aid, with ants. In return for shelter and food, the ants protect their hosts from insect enemies. The shelter is afforded by peculiarly formed leaves and cavities in stems; the food consists of honey and of minute excrescences which contain much albumen and are known as "Mueller's corpuscles." It is not yet decided whether these cavities and corpuscles are directly useful to the plant or result from adaptation to the needs of the ants.

The complex organization of the ant commonwealth and the harmonious co-operation of all its citizens have often been cited as evidence of intelligence of a high order, but this theory may now be classed among the vagaries of the science of the nineteenth century. The actions of ants are governed almost entirely by the sense of smell, which is located in the antennæ. The loss of these organs produces complete helplessness; the amputation of the antennæ of all the ants of a com-

FIG. 22.—*A*. MITE CLINGING TO ANT'S JAW. *B*. BEETLE ATTACHED TO ANT'S ANTENNA.

munity destroys every social instinct, and the state falls asunder. It has been proved by experiment that ants possess not a trace of higher intelligence or knowledge of the connection between cause and effect. They are unable to draw the simplest and most obvious inferences and they cannot be induced to do anything foreign to their normal habits and instincts.

For example, a piece of tin covered with honey was placed across a much-frequented ant path, and so arranged that it could be elevated very gradually. The ants greedily lapped the honey while it remained within their reach and afterward they vainly endeavored to get at it by standing on their hinder legs, but they did not know enough to heap up a little earth and ascend the mound, although they constantly perform similar operations in building their nests. Experiment has likewise shown that the earth bridges which ants throw over barriers of tar or molasses are not intended as bridges, but are made in obedience to the instinct of cleanliness which impels ants to cover with earth any offensive matter that they cannot remove. The same instinct explains the so-called "funerals" of ants. The most complex and apparently intelligent actions of ants are based, not on reason, but on inherited instinct. The warlike amazon ant is a marvelous strategist but unable to feed itself and even its military tactics are never modified in accordance with varying conditions.

These examples and many others show that, if we concede to the ants the possession of the high order of intelligence which Buechner and some others ascribe to them, their life will appear full of strange inconsistencies and their limitations will seem even more remarkable than their abilities. The mental development of ants ceases at pupation. They do everything as perfectly on the first day of adult life as on the last, and in exactly the same way. They can learn something,

FIG. 23a.—HEAD OF AMAZON.

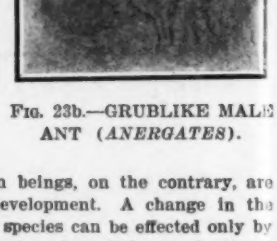


FIG. 23b.—GRUBLIKE MALE ANT (*ANERGATES*).

but very little. Human beings, on the contrary, are capable of continued development. A change in the instincts of a given ant species can be effected only by the operation of altered external conditions and natural selection continued through many generations.

In short, man's brain is plastic and can do many things, while the ant's brain is automatic and must do certain things. The communities of ants and those of men rest on essentially different foundations, and the resemblances between them are either superficial or fortuitous. The immense difference in the proportion of brain weight to total weight, in the two species, proves this more clearly than volumes of theoretical speculations.

The Rev. Father Oldenbach, S. J., of St. Ignatius College, Cleveland, has conceived the idea of establishing a network of seismic stations around the world to co-operate with the Central Bureau of Strasburg. It is difficult, if not impossible, at present to obtain seismograms which are comparable. Grams of different instruments or of the same make with a different adjustment are not of this nature. The Central Bureau has no means of commanding such material, and it is for this reason that Father Oldenbach has set a movement on foot, which in his opinion will serve to build up a new seismology. He is enlisting in the service Jesuit colleges scattered over all parts of the world. By installing instruments of the same make and adjusting them on a uniform plan, he expects soon to produce seismograms which will be of incalculable value to the student of seismic phenomena. Strasburg will determine the adjustment and other minor details. The instruments chosen will be the Wiechert

FIG. 24.—ANTS AT PLAY.

astatic pendulum, with a steady mass of 80 kilogrammes, a period of from 4 to 12 seconds, a sensitiveness of 1 to 15 millimeters per degree of arc, and a registering velocity of 1 to 15 millimeters per minute. The stations thus far secured are located as follows: Georgetown, Brooklyn, Worcester, Buffalo, Cleveland, Toledo, Mobile, Chicago, St. Boniface, Manitoba, St. Mary's, Kan., Denver, Col., San Francisco, Santa Clara, Cal., Spokane, and Seattle, Wash. When this system is well under way, it will be extended to the other countries. Such stations as Bulawayo, Africa, Darjiling in India, and Titicaca, South America, will be founded.

NITRATE OF SODA.*

ITS CONSUMPTION IN THE UNITED STATES.

BY CHARLES E. MONROE.

ON November 10th, 1904, I had the honor of calling the attention of the members of the Washington Chemical Society to the fact that as the statistics for the chemical manufactures had come to be taken by the Bureau of the Census they could be made use of in solving many problems of interest and value, provided only that they were properly used, and I pointed out that one of these problems was that of ascertaining the principal industries in which a given material was used and the extent of its use in each industry. The results of this process as applied should prove to be not only of general scientific and economic interest, but also of special value in legislation and litigation where the rule of "principal use" obtains; in determining tariffs and levying taxes; in fixing freight rates; in manufacturing and other operations where the question of substitution may arise; and in other special instances. In the investigation work of the census itself such data furnishes additional checks on the returns.

The application of this method was illustrated by taking sulphuric acid as an example, since this is the substance of fundamental importance in the chemical industries, and there was presented, in tabular form, the results obtained. These results, after further checkage, have been published on page 23 of "Chemicals and Allied Products for 1905," this being Bulletin No. 92 of that census of manufactures.

Attention having been called to the proper use of the statistics of the census it may be well to state here that, where the chronology is of importance one should be careful to ascertain the period of time to which any given census statistics refer, because, in a census of manufactures, the data record transactions already completed at the time the investigation was made, and because of changes in the law, as enacted by Congress, the yearly periods covered may not be similar and the intervals between the sucessive censuses may not be of precisely the same length. In illustration we have the census of 1900, covering the operations for the year ending May 31st, 1900, and the census of 1905, covering the operations for the calendar year ending December 31st, 1904, except for the State of Michigan, where, for the purpose of co-operation with the State authorities, and to avoid duplicate enumeration in the same year, the statistics were collected for the year ending June 30th, 1904.

Also it may be proper to point out the chance of error which may arise from making use of census data without consulting the text carefully so as to ascertain to what the data applied. Thus, if one wishes to obtain the statistics for the chemical industries of this country at the census of 1905 he might consult Table CX on page clxxi, of Part I, and find the value of the products given as $1,031,965,263, or he might consult Table 1 on page 398 of Part IV and find the value of the products given as $323,997,131, or a difference of over $707,000,000 in the value of products for the same period of time. But on investigating the tables and their accompanying text we find the first to cover the "Chemical Group" and to embrace a large part of those substances found in chemical technologies, while the second table treats only of those substances styled in the census classification, "Chemicals and Allied Products." Also, to take another example, we find from Table 8, page 404 of Part IV, that the sulphuric acid produced at the census of 1904 was 467,614 tons, while from Table II on page 405 of the same part, the sulphuric acid produced is reported for the same census as 1,869,437 tons, both being for 50 deg. Bé. acid. From inspection of the text we find there is no discrepancy between these figures, but that the first table treats only of the products of those establishments which are included in the census class of "sulphuric, nitric, and mixed acids," while the second table gives the total sulphuric acid produced not only for sale, but for consumption also, by establishments of all kinds.

What is true of products is also true of materials used in manufacture. They may appear in different reports represented by different numbers and yet each of the statements may be correct. Such a condition of affairs may be repeatedly met with in the Reports on Chemicals and Allied Products, and it is here especially that the text should be scrutinized, since each of the Special Reports for 1900 and 1905 embraces nearly two score of classes and some thousands of industries and, in order to present the true condition of each of several industries, it has been necessary to duplicate some of the data.

Thus if we examine the statistics of the class styled "Fertilizers," we find nitrate of soda enumerated as one of the materials used in this manufacture, and that it is used in this industry not only as a direct component of mixed or compounded fertilizers, but also in the manufacture, within fertilizer factories, of sulphuric acid by the chamber process. Again if we examine the report on the class styled "Explosives," we find that nitrate of soda, as a material used, is used not only as a component of blasting powder and of dynamite, but also in the manufacture, within explosive factories, of nitric acid and also of saltpeter or potassium nitrate. In order then to completely set forth the sulphuric acid, or nitric acid, or saltpeter industries, the quantities of these substances produced in fertilizer or explosives establishments, and of the materials used in their production, must be reassembled and presented anew.

Two methods for presenting the satistics of the consumption or distribution of the materials of manufacture are thus indicated. (1) By the classes of products in the manufacture of which the material is consumed both directly and indirectly. (2) By the products in the manufacture of which the material is consumed directly only though some of these products may constitute the raw material of further manufacture. The data under the first category are those which are reported by the establishments in gross, and may be taken directly from the published census tables. The data under the second category must, on the other hand, be obtained by analyses of the data returned for each class, assigning the proportion of the material consumed in the manufacture of each intermediate and each final product, and then assembling that consumed in the direct manufacture of each single product.

Proceeding in this manner for nitrate of soda, I find:

(1) NITRATE OF SODA CONSUMED IN THE UNITED STATES BY ESTABLISHMENTS CLASSED AS FOLLOWS:

Class.	1900. Short tons.	1905. Short tons.
Fertilizer industry	19,518	42,213
Dyestuffs industry	223	261
General chemicals industry	35,990	38,048
Glass industry	10,770	11,915
Explosives industry	88,924	133,034
Sulphuric, nitric, and mixed acids industry	27,006	29,301
	182,431	254,772

(2) NITRATE OF SODA CONSUMED IN THE UNITED STATES CLASSED BY PRODUCTS IN WHICH IT IS DIRECTLY USED.

Products.	1900. Short tons.	1905. Short tons.
Compounded fertilizers	13,058	34,795
Dyestuffs	223	261
General chemicals	30,287	31,324
Glass	10,770	11,915
Explosives	76,696	100,985
Nitric acid	30,213	50,301
Saltpeter	5,703	6,724
Sulphuric acid	15,481	18,467
Total	182,431	254,772

An attempt has been made to check these totals by comparing them with the quantities of nitrate of soda reported by the Bureau of Statistics as having been imported for consumption in the United States during the fiscal years 1899 and 1904 and 1905, taking the average of this latter two-year period. These quantities are reported in long tons, while the census quantities are given in short tons. As reduced we have 206,357 short tons as being available at the census of 1900 and 322,709 short tons as being available at the census of 1905. There is therefore 23,926 short tons of nitrate of soda for 1900 and 67,937 short tons for 1905 not accounted for in the tables which may be charged up to all other uses and products, such as enameling, metallurgical flux, pickling, and the manufacture of minor chemicals. These last figures must be regarded as mere approximates, since stocks of nitrate are frequently hoarded and then brought out when there is a specially active demand for them, and it may therefore happen that the consumption in this country for a given year may exceed or fall below the imports for that year.

The results set forth in the tables, though not exhaustive, are of interest, especially in the item of fertilizers, for there is a widespread belief that nitrate of soda is most largely consumed in agriculture, yet such does not appear to hold true in this country. But the conditions which obtain in this industry in the United States vary widely from those which obtain in European practice, for, in the United States, besides nitrate of soda and ammonium sulphate, large quantities of other nitrogen-containing substances are used in compounding fertilizers. Thus the statistics of the census of 1905 show that in that census year there were used for this purpose, besides the nitrate of soda, 10,540 tons of ammonium sulphate, 923,305 thousand fish, 125,888 tons of ammoniates, 1,160 tons of saltpeter, $2,376,448 worth of cottonseed meal, and $5,094,149 worth of bones, tankage, and offal.

The menace to an extension in the use of nitrate of soda in the United States is found:

1. In the increased use of by-product ovens for coking coal, it having been shown* that but 3,317,585 tons of the 37,376,251 tons of coal coked in this country in the census year 1905 were coked in by-product ovens and that if all had been so treated there would have been produced 359,560 tons of ammonium sulphate instead of 15,773 tons which was the actual yield from this source.

2. In the substitution of contact processes for chamber processes in the manufacture of sulphuric acid.

3. In the discovery of calcium cyanamid or lime-nitrogen because an extensive plant is now being erected at Niagara Falls for its production, and

4. In the introduction of electric processes for the manufacture of nitrates from atmospheric nitrogen.

* Read at the Baltimore meeting of the American Chemical Society.

* Bulletin No. 65, Census of Manufactures, 1905. Coke.

A NEW METHOD IN CRIMINOLOGY.

RECENT transactions of the French Academy of Sciences contain the description of a method of investigation by which the author of a crime can be detected in many cases in which all evidence appears to be wanting. Hitherto the efforts of experts in projectiles have been necessarily confined to determining whether a bullet found in the body of the victim or in its vicinity was fired from a weapon found in the possession of the accused person. Dr. Balthazard has recently succeeded in proving that two bullets found, respectively, one day and three weeks after the crime, had actually struck the victim. These bullets had made wounds in the arm without entirely penetrating the clothing, and had then fallen to the floor. Balthazard observed that the bullets showed distinct impressions of the texture of the coat. He stretched a piece of the same fabric upon a board, fired at it with leaden bullets and obtained similar impressions, thus proving with reasonable certainty that the bullets found upon the floor had hit the victim. This result led him to make further investigations, in the course of which he discovered that projectiles which have passed through garments, even if they have subsequently penetrated very deeply into the body, invariably show distinct impressions of the texture of the garments, except when the bullet has been deformed by striking a bone. The method of investigation founded upon these results consists in stretching the fabric of the garment over a smooth board, and firing at it with bullets of the same size as the suspected ones. In practice it suffices to employ a revolver of the caliber most frequently used and cartridges of small power, so that the bullets fall to the floor without penetrating the wood. It is merely necessary to measure the distances between the grooved lines found in the bullet in order to determine the nature of the fabric struck by it. It is still simpler to count the number of furrows in a distance of 1/10 inch along the warp and the woof. In many cases the difference between the coarse warp and the much finer filling is so striking, that the fabric can be immediately recognized. Shirt bosoms and collars, which are composed of several layers of fabric of which the outermost is the finest, produce on the bullets a compound impression showing the traces of the several fabrics. By means of this ingenious method, Balthazard is able to determine the particular garment worn by the victim of a murder and, if there are several wounds in the body, to show through which the bullet has entered. He intends to publish an album of photographs of the impressions made on bullets by various fabrics, for the purpose of facilitating the employment of this new method in criminology.—Umschau.

A fuel-testing plant is being established by the Canadian government for investigating the natural fuel supplies of the Dominion. As peat occurs in immense quantities in both Ontario and Quebec, an attempt is to be made to discover a method of using it successfully in gas producers.

THE "GEORGE WASHINGTON."

THE NEW NORTH GERMAN LLOYD STEAMER.

THE "George Washington" is the latest addition to the fleet of the North German Lloyd, and extraordinary efforts have been made to make the new steamship in every way worthy of its great name. In striving to carry out this plan one of the greatest decorative artists of Germany made a special trip to the United States for the sole purpose of studying Washingtonia, that the magnificent pictures which adorn the great assembly rooms of the steamer might be authentic and in keeping with the name and fame of General Washington.

The American ambassador to Germany, Dr. David Jayne Hill, christened the "George Washington" and with his secretaries was on board at the successful trial trip, when the "George Washington" made an average speed of 20 knots per hour over a measured course.

The "George Washington" is the first great transatlantic liner to be decorated in the new style of applied art.

The architects of interior decoration and design were given the utmost freedom, and have produced the most exquisite results.

Far more arduous conditions exist in this work on a steamship than in a hotel, apartment house, or residence. On board a steamship the designer provides a framework of iron columns and girders which cannot be gotten rid of, odd corners, curved sides, and with all these disadvantages to contend with the interior architects must transform it into a harmonious whole.

The style of interior decoration and furnishing adopted recalls our own Colonial type, the substantial, simple, and dignified elegance of this period having displaced the more ostentatious glitter and glamor which have been such a noticeable feature of steamship decoration.

The roominess so characteristic of the Colonial is typical of the great assembly rooms and cabins of the "George Washington." The leading architects for interiors in Germany have surpassed themselves in the perfection attained in the work of this new steamship. The adaptation of this style to modern requirements has resulted in an exceedingly dainty and delicate combination.

The reading room was on exhibition at the Munich Exposition, and was most favorably commented upon. It is in subdued tones, without external ornamentation, giving an air of distinguished restfulness. By reason of its simplicity the idea of spaciousness is much enhanced. An ingenious arrangement of the furniture adds to the architectural effect. The bookcases are let into the walls between the permanently fixed writing tables, utilizing every nook and corner to the best advantage.

As an example of the resourcefulness of Prof. Paul, his arrangement of the lounges in this room was the subject of unusual comment by those who visited the Munich Exposition. In this room are a number of iron columns, necessary in the construction of the vessel, yet in his arrangement of lounges Prof. Paul utilizes the columns in such a manner as to eliminate them as disturbing elements, and so as to add to the usefulness and beauty of the room.

For those who wish the very acme of luxury while traveling are two "imperial suites," as they are technically known. These consist of drawing room, breakfast and dining room, bedroom, fitted with brass beds and bath, together with all toilet accessories.

Next in point of elegance are the suites, of which there are two, each consisting of drawing room, bedroom, and bath. On the promenade deck with the imperial suites and suites are twenty-four *cabines de luxe* of great size with bath. There are seven other *cabines de luxe* with bath, but these are on the saloon deck, making in all thirty-one *cabines de luxe* with bath. These *cabines de luxe* have accommodations for three persons. Even with this number in a *cabine de luxe*, each passenger has a lower berth.

BREAKFAST ROOM OF IMPERIAL SUITE.

In the rooms of this character there are no upper berths, which arrangement, together with the richness and sumptuousness of the furnishings, great size, and large square windows, gives the impression of an apartment ashore.

In addition to these rooms there are a number of large, handsomely fitted cabins in the first class for one, two, and three persons.

The imperial suites on the "George Washington" were designed by Rudolf A. Schroeder, who has striven most successfully to meet the needs of a class accustomed to luxury, not, however, by anything in the way of ostentatious display, but rather by that quality of refinement peculiar to the old French designers of furniture, but without in the least imitating them.

The "George Washington" will be richly embellished with mural paintings commemorative of the life and times of the first President of the United States.

Otto Bollhagen, the celebrated Bremen fresco artist, made a special trip to the United States, where he visited Philadelphia, Mount Vernon, Washington, and other places associated with Washington's history for the purpose of securing data and local color.

Nearly all of the first cabin rooms are so high above the water-line that the windows may be left open even in the roughest weather, insuring an abundance of fresh air and light.

All of the public rooms, imperial suites, suites, *cabines de luxe* and rooms on the upper deck are fitted with large, square windows.

On the "George Washington" will be found accommodations for an additional or third class of passengers. This establishment of a third class was done by the North German Lloyd to meet the wants of those who find the prices charged for second-class passage too high, yet who do not wish to travel in the steerage.

The rooms for passengers of the third class are in the after part of the vessel, and are arranged to accommodate two, four, and six persons. Third-class passengers are provided with a smoking room and drawing room on the promenade deck and with a dining room on the saloon deck.

The open space of the upper saloon deck, aft, and the deck space over the steam steering house, aft, are reserved for this class of passengers.

The cabins for passengers of this class, while not as elaborate as those of the first and second class, contain all necessaries for making the trip comfortable, such as wash-stands, mirrors, wardrobes, etc.

The "George Washington" is constructed as a first-class twin-screw passenger and freight steamship with keelson and flat keel, vertical stem, elliptical stern, and bilge keels. The vessel is equipped with a water-tight double bottom, extending the entire length, divided into twenty-six compartments. In the various compartments, 138,250 cubic feet of fresh, drinking, and ballast water may be carried.

Twelve water-tight transverse bulkheads, all reach-

RECEPTION ROOM OF THE IMPERIAL SUITE.

BEDROOM OF A SUITE.

THE NEW NORTH GERMAN LLOYD STEAMSHIP "GEORGE WASHINGTON."

ing to the upper deck, and some even to the upper saloon deck, divide the ship into thirteen water-tight compartments, so arranged that even though two adjoining compartments should fill with water, the ship's stability would in no wise be affected. The bulkheads are constructed in accordance with the rules of the Germanic Lloyd and are so strong that one-sided water pressure can easily be withstood.

Two separate stairways are provided for all rooms below the saloon deck, between every two water-tight

A GLIMPSE OF THE READING ROOM.

bulkheads, making it possible, without disturbing communication, to keep all bulkhead doors below this deck closed during the night or in foggy weather, adding greatly to the safety of the ship and its passengers. Of the thirty-six water-tight doors, eleven below water level are equipped with the Lloyd-Stone closing device, first installed on the steamships of the North German Lloyd and now adopted by every great line. This device enables the doors to be closed by the simple turning of a wheel on the bridge deck. These doors may be closed and the ship practically hermetically sealed within fifteen seconds. Hydraulic power closes the doors, but in order that the captain and ship's officers may know whether or not a door is closed, there is a diagram in the chart house, and as each door closes a small incandescent light flashes up. Should, for any reason, a door not be closed by the hydraulic pressure, it may be shut by hand.

Other safeguards for the ship and passengers are a bell system for fire-extinguishing purposes, with fourteen alarm bells leading to the main quarters of the crew; a complete alarm-bell system, with thirty stations for the ship and engine-room system; a fire-reporting system, with eighteen alarm stations scattered over the vessel; submarine bell signaling apparatus, permitting the ship's officers to know of the proximity of another vessel or coast when from seven to twelve miles distant. This system is of benefit in enabling the ship's officers to keep to their course when approaching or leaving port in foggy weather.

Among the other safety devices on board are the wireless telegraph station, enabling passengers to keep in communication with the land at all times, a complete system of telemeters, engine telegraphs, rudder telegraphs, etc.

Some of the innovations of the "George Washington" are the elimination in the cabins of the first class of upper berths, great number of rooms with baths, children's playroom, two electrically-worked elevators for passengers, a great solarium or lounge, sumptuously fitted and furnished, and covered by a great vaulted dome of cathedral glass; complete electrical equipment, extraordinarily wide berths, great two-storied smoking room for passengers of the first class, magnificently equipped gymnasium, electric light baths, hot and cold and fresh and salt water at all times, running water in rooms, dark room for the use of amateur photographers, and on the boat deck are twenty specially constructed dog kennels, in charge of a competent kennel master, where the pets of passengers may be placed during the trip and at the same time receive the best of care.

Some idea of the colossal proportions of this ocean giant may be had from the following dimensions of the vessel:

Length, 722 feet 5 inches; beam, 78 feet; depth from upper saloon deck, 54 feet; depth from awning deck, 80 feet; speed, 18.5 knots; displacement at 33 feet draft, 37,000 tons; gross registered tons, 27,000; horsepower, 20,000; cargo capacity, 13,000 tons.

PHOTOGRAPHS IN NATURAL COLORS ON PAPER

By A. BERTHIER.

VARIOUS methods of producing photographs in natural colors on paper have been suggested, but the results obtained are far from satisfactory. In the three-color mosaic processes (Lumière, Jougla, etc.) the silver precipitated necessarily injures the reproduction of colors seen by reflection. I have made some experiments with a view of suppressing the reduced silver and, consequently, the small opaque areas which mask the complementary colors. The principle of my method is briefly as follows: It is based upon the employment of exceedingly fine particles analogous to Lumière's starch grains; but while the colored starch remains soluble, so that the colors are affected by water, my small elementary surfaces are formed of insoluble substances. Let us suppose that fibers of cellulose (artificial silk), colored blue, yellow, and red, are mixed together in parallel bundles and cut transversely with a microtome. Thus we obtain a powder composed of red, yellow, and blue disks or cylinders, intimately mixed together. This powder is strewn upon a layer of gelatin, and the sensitive orthochromatic emulsion is spread directly upon it, without the interposition of the varnish used in the Lumière autochromes. The plate is exposed like the autochromes, the developed image is reversed and redeveloped, producing a diapositive, which is then sensitized with potassium bichromate and exposed to full daylight. The gelatin in the parts protected by the deposit of silver remains soluble, while the gelatin not so protected becomes insoluble. The silver image is then removed with acid permanganate solution or with Farmer reducer or by converting the silver into chloride and dissolving it in hyposulphite. The chrome-gelatin picture can then be developed in hot water as in the ordinary carbon process. Thus all that is left is the insoluble particles of colored cellulose, and a clear positive is obtained in which the colors are not masked by any opaque substance. In the plates obtained by the ordinary three-color processes the colors are produced by concealing the colors which are not wanted, for example, red is produced by masking the blue and yellow particles by silver. Hence the picture produced by my method is much brighter and, furthermore, is visible by reflected as well as by transmitted light. All that remains to be done is to transfer the film to paper, cardboard, or wood. I intend to seek a modification of this process which will permit the multiplication of copies. Instead of producing a positive in the first place, a negative would be produced by omitting the inversion and redevelopment. This negative would be sensitized by bichromate as described above, and, not containing any opaque particles, it could be reproduced by contact.

It is evident that this method is quite complicated. Furthermore, it would probably give good results only for pure colors, red, yellow, and blue. For the intermediate tints it would be necessary to employ excessively fine particles. Evidently none of these particles could be modified, as it is insoluble and the positive silver has been removed, so that the variations of color could be obtained only by combinations of entire particles. In the autochromes a starch grain may be masked by silver to a greater or less extent. It is in the hope that some ingenious photographer will find the solution of this difficulty that this sketch of my method is here presented.—Cosmos.

In considering coal for boiler plants, it is necessary to know the coals which are available and their relative values. Some otherwise good coals may be unsuited because of trouble from clinker. Not always, but generally, the cheapest coal to buy is the lower-priced one, provided conditions in the plant will permit its use. In order to compare the cost of coals offered to the government they have been calculated on the basis of the cost of one million heat units delivered. This varies from seven to twenty cents in different parts of the country. If the purchaser desires assurance that the same coal which he selects shall be delivered throughout the contract period, he naturally desires to make use of specifications covering the essential characteristics of the coal. The United States government, many State and city governments and numerous commercial firms are now using such specifications with success. The specifications cover such items as price, method and time of delivery, and also establish a standard for the heating value of the coal, and the ash content. In some cases the permissible amount of volatile matter is stated.

THE WRITING ROOM.

THE NEW NORTH GERMAN LLOYD STEAMER "GEORGE WASHINGTON."

THE NEW AUTOMOBILE STEELS.*

THEIR USE IN MOTOR-CAR CONSTRUCTION.

BY JOHN A. MATHEWS, PH.D., SC.D.

AT the beginning of the twentieth century there was no automobile industry; to-day, before one decade has passed, we see a new industry of imposing magnitude. There are in the United States over two hundred and fifty makers of automobiles, and this number does not include makers of commercial motor vehicles and trucks. In short, it refers to makers of cars primarily for pleasure purposes. Upward of one hundred thousand employees are directly engaged in these factories, and not less than four thousand allied industries and works are more or less dependent upon the motor-car industry. Truly this is remarkable growth, and if, by reason of its years, this is still an "infant industry," all must admit that it looks like a thriving infant.

The value of sales of cars of domestic manufacture during the past six years is approximately two hundred and fifty millions of dollars, while over fifty millions have been spent upon foreign made cars.

As regards the productive cost of automobiles, both foreign and domestic, it appears that about 30 per cent of the expense goes for wages and 60 per cent for materials of construction. The remaining 10 per cent represents salaries and materials for plants. Since 60 per cent of the entire expense of manufacturing cars represents materials, no apology need be offered for presenting a paper before this institute upon the *kind* of materials best suited for the construction of the vital parts. In this paper we propose to consider certain economic phases of the subject together with some matters of shop expediency and the relation of various manufacturing methods to the *quality* of the finished parts. We use the term "vital parts" advisedly because upon the quality of materials used in certain parts, the safety and even the life of the automobilist depends.

The exigencies of the demands of motor-car construction have proven a wonderful stimulus to the metallurgy of special steels. The heavy moral responsibility which rests upon both the maker and user of alloy steels and the tremendous duty expected of these materials of construction—lightness without sacrifice of toughness or strength—tend to make the requirements of the automobile trade most exacting.

While a few makers of automobiles and still fewer makers of steel accept this view and realize their grave responsibility, by far the majority of them seem lacking in this conception of their duty. With the steel maker it is too frequently a question of great tonnage only, and with the customer it is a question of buying at the lowest price, without due consideration of what the consequences of using cheap and inferior materials may be.

There are any number of steel makers who can display choice samples of their wares; the number of those who can furnish the same thing twice on order is much smaller. It is the ability to deliver the same article twice that makes for success in the manufacture of alloy or tool steel.

During the recent commercial depression the automobile industry thrived while the steel industry languished. A ruinous competition has been waged in the alloy steel business, and these products have, in general, been sold at absurdly low prices, wholly inconsistent with that consideration of quality which motor-car construction deserves. This has retarded progress in the development of new steels.

It is inconceivable to my mind how any firm can conscientiously put out a car and not know intimately the materials used in every essential part. Yet such is frequently the case—gears are bought from "A" solely because his price is lower than that of "B" and "C," but the materials from which they are made are often unknown to the purchaser and rarely specified excepting perhaps in a general way. For example, nickel steel is asked for. Now nickel steel is a delightfully variable and uncertain quantity as ordinarily made. To say that you use nickel steel is about as definite as to say that you own an automobile—it may be a Packard limousine or a farmer's high-wheel auto-buggy. Both run by their own power on four wheels, but there the resemblance ceases. There are of nickel steels—like pickles—at least fifty-seven varieties, and the user should know what *kind* of nickel steel goes into his gears and who makes the steel as well as the gears.

Dr. Guillet, the distinguished French metallurgist, has previously pointed out that the constitution and mechanical properties of nickel steel depend essentially upon the sum C + Ni. From my own experience I should add to this sum + Mn. One hears continually in the trade nickel steel referred to solely by its percentage of nickel. Such expressions possess no real significance as a measure of quality or adaptability for various purposes. It is the skillful blending of the elements C + Ni + Mn that counts, and the successful accomplishment of this is a fine art. Almost as bad as not specifying at all is the tendency upon the part of many buyers to tell the maker how he ought to make his steel; to specify chemical analysis and physical tests which are a misfit, and, to quote Dr. C. B. Dudley, to make the wording of the specifications "a place to show how much they know, as well as (to display) a mental attitude of favor or antagonism to any of the parties affected by it." I wish we might consider somewhat fully the subject of specifications, but for want of time I can only refer to Dr. Dudley's presidential address to the American Society for Testing Materials, in July, 1903. It would be useless for me to attempt to add anything to what Dr. Dudley has so well said. Permit me, however, in passing to quote a few of his words:

"A specification for material should contain the fewest possible restrictions, consistent with obtaining the material desired. The service which the material is to perform, in connection with reasonably feasible possibilities in its manufacture, should determine the limitations of a specification. All parties whose interests are affected by a specification should have a voice in its preparation. Excessively severe limitations in a specification are suicidal. They lead to constant demands for concessions, which must be made if work is to be kept going, or to more or less successful efforts at evasion. Better a few moderate requirements rigidly enforced than a mass of excessive limitations which are difficult of enforcement, and which lead to constant friction and sometimes to deception."

In these few words Dr. Dudley has spoken volumes and his entire address, "The Making of Specifications for Materials," will repay earnest study.

In my address this evening it is not my intention to weary you with long tables of analyses and physical tests. Perhaps a few will be mentioned incidentally and more added in an appendix. What I especially desire to emphasize are certain economic features in connection with the manufacture, purchase, use, and treatment of alloy steels of various types. Not all parts of an automobile demand especially high-grade material, while some parts demand the best of alloy steels. Indeed their use might well be made compulsory in the interest of public safety. We have seen manufacturers err in using too good materials in unessential parts, but the opposite tendency is more general.

Sound business judgment demands the best materials in vital parts, first, because of increased safety; second, because of the reduction in the guarantee cost, and third and most important, because of the advertising value of a clean score on breakage for a whole season's output. Dynamically strong axles, tough and strong steering parts, and springs which neither sag nor break are essential to comfort and safety. The crankshaft ought to be stiff and strong, the valve mechanism must resist wear, and the valve springs must retain their resilience indefinitely. Connecting rods, cap screws, clutch springs, gears and shafts, all moving and sliding parts of the transmission, bevel driving pinions and driving shafts, truss rods and torsion bars, all have more or less severe duty to perform and require materials possessing in various degrees resilience, strength, toughness, wearing qualities, and anti-fatigue qualities of high order. To make these parts of cheap and inferior stuff is not a good business proposition. The failure of such parts injures the reputation and name of any car and it is well to remember that contented owners of cars are their best advertisers.

As a manufacturer endeavoring to produce at all times the best qualities of tool and alloy steels, I see and hear much of that class of buyers to whom price is the all-important consideration. The ability, honesty, and reputation of the steel-maker carry no weight with them. A quarter of a cent difference in price far outweighs any considerations as to the relative knowledge, experience, or facilities of competing makers. You can't get something for nothing and if you get something for next to nothing it is likely to cost you dear in the end. Let us consider what it means, for example, to buy a satisfactory steel for gears—one which will produce gears that will never break—and a mediocre steel costing three-fourths as much from which some trouble is inevitable. A fair cost for a transmission, complete, would be perhaps eighty dollars; of this amount the steel for the gears themselves might cost ten or seven and one-half dollars, or one-half or three-eighths of one per cent respectively of the $2,000 car. By using the better steel you have increased the cost of your complete transmission a little more than three per cent and the cost of the car by one-eighth of one per cent. This minute increase might readily represent the difference in cost involved and the results attained might well be considered very cheap advertising. Very few automobile makers are manufacturing on such a close margin of profit that they can afford to risk failure through false economy. The difference between a good and a poor steel of any particular class rarely exceeds two cents per pound. If the design is right and parts not needlessly heavy and if proper discrimination is shown in the selection of the right steels for various parts, the difference in raw material cost will amount to but a small percentage increase in the final cost and as an investment will be better than Standard Oil stock at par. The product is vastly improved; the car is safe and reliable; it advertises and sells itself.

I hope you will pardon me, if I digress for a few moments and tell you something of the steel company which I have the honor to serve as manager. We have good reason to take pride in our mill and equipment, and if any of you have ever visited our works I am sure you will confirm me in this. In general new steel mills are given considerable attention by the technical press and full descriptions are published with illustrations. Suffering from excessive modesty or other cause, very little has been given to the press about our plant. The Halcomb Steel Company is not even as old as the automobile industry. It is new in one sense only, however, it is a newly incorporated company with a new plant. Within five years it has erected the largest steel works in the United States devoted exclusively to the manufacture of high-grade tool and alloy steels. Competent authorities tell us we have the best arranged mill and equipment in the world for our class of work. That may seem a strong statement but I am quoting the opinions of English and American steel men and not my own. When the "Lusitania" made her maiden trip she was not manned with longshoremen. No, the best men in the employ of the Cunard Company were promoted; experienced men only were wanted. So in our plant, modern from stem to stern, we have an old mill organization of proven ability that has weathered many storms. Our working organization of department superintendents and foremen, intact almost to a man, has been associated for upward of twenty years in the manufacture of tool steel. Their fathers and grandfathers were steel men and their sons are following in the same occupation. Sheffield hasn't a monopoly upon ancestry in the tool-steel trade. We have men of the fifth and sixth consecutive generations of steel-makers with us and we cling tenaciously to the best methods and traditions of Sheffield tool-steel practice as regards the crucible process. We also have the first commercial electric steel-melting furnace erected on the Western Hemisphere. For three years the Heroult electric process has been used in our works. We thus combine conservatism and progress in our selection of methods of steel-making.

When we took up the manufacture of alloys for automobile construction we engaged as metallurgical engineer a man experienced in automobile engineering, a man familiar with specifications, testing and heat treatments, the design and construction of cars, and familiar with the troubles that have been encountered by the automobile manufacturers. In making these new alloys we want more knowledge of them than a chemical analysis and a tensile test. We consider the proposition in its entirety, including machining qualities and corresponding productive costs in the user's shop.

We manufacture many types of alloy steel but, of course, have our preferences. Upon request we can furnish expert advice in reference to the choice of materials for various parts and are pleased to co-operate fully with those desiring the best material in every part. By studying individual constructions, the expense of needlessly good material in unimportant parts is prevented while just the right thing for essential parts will be recommended.

No alloy steel is a universal steel. They must be selected with fine discrimination, giving due thought

* Journal of the Franklin Institute.

to the duties they must perform. Obviously the careful maker should be more intimately acquainted with his products than the user can be, both as regards chemical and physical qualities and thermal treatment and, hence, we willingly place our years of scientific and practical experience with alloys at the service of users of these products.

Quality rather than tonnage is our first desire. Each product must be the best of its kind; it must be uniform, year in and year out; it must be physically sound, free from pipes and seams and pass rigid inspection. In short our alloy steels are handled with all the care and minute attention to details affecting quality that characterize our finest tool steels. This way of doing business costs money. When I mentioned a few moments ago paying a few cents a pound more for a good steel, that is just what I meant. I did not mean that one should pay ten cents for a seven-cent steel. That won't improve the quality of the steel. I maintain that purchasing a steel worth ten cents is in nine cases out of ten economy over a steel worth seven cents, for use in vital parts.

Without attempting any scientific classification of alloy steels, or enumerating all types that have been used at home and abroad, I will briefly describe the principal types used in the American trade.

Nickel steel is perhaps the most generally used of the alloy steels. Its merits are often obscured by irresponsible makers whose product lacks uniformity—we have even heard of the nickel itself being omitted. The analysis usually desired but not always attained is, carbon 0.20 to 0.25, nickel 3.50, manganese 0.60 to 0.90, sulphur and phosphorus not over 0.04. With carbon and nickel as above stated manganese ought never to exceed the limits mentioned. A slightly lower carbon is sometimes used for case-hardening purposes, and a higher carbon is much used for crankshafts. With higher carbon we should prefer lower manganese. A small quantity of 5 per cent nickel steel is used in about the same carbons. Certain firms claim to sell crucible nickel steels in these compositions; personally, I have never known of a pound of such steel being made commercially, and the prevailing price of nickel steel is pretty substantial evidence that it has not been produced by the crucible process. It is usually made in the basic open hearth furnace; with reasonable care, however, nickel steel can be made uniform, physically sound, and free cutting. It has remarkably good mechanical qualities when subjected to suitable heat-treatment and is an excellent steel for case-hardening. In machining qualities it usually takes first place among the alloy steels. When extraordinary care is used in its manufacture, and it is not made in too large heats or ingots, and when piping and segregating are avoided by confining the finished product to that produced from the bottom two-thirds of the ingot, we have an admirable product for many purposes. In manufacturing such steel in the electric furnace, only relatively small ingots are made wherein segregation and piping are negligible.

Chrome vanadium steels in a profusion of types have of late attracted the profound attention of automobile engineers. Mr. J. Kent Smith has but recently discussed these products before this Institute, and his work in connection with these steels is deserving of the highest praise. As an illustration of the novelty of vanadium steel as a commercial commodity, I well recall being quoted $75 per pound for vanadium not many years ago.

The chrome-vanadium alloys are preferably made in the crucible or electric furnace, although the open-hearth process is also much used for the purpose. The open-hearth product, I believe, is somewhat uncertain and while, for example, an open-hearth chrome-vanadium spring-steel may be better than plain carbon crucible spring, it is not to be compared with genuine crucible chrome-vanadium steel when properly melted. For excellent quality, this product constitutes the highest attainment of the steel-maker's art.

These alloys are, in general, made in a high carbon type, suitable for oil-hardened gears and springs, and in several low carbon types—such as a case-hardening type for gears and a type suitable for oil quenching followed by annealing for axles, shafts, and steering knuckles. By judicious blending of chromium and vanadium and adjustment of the manganese and carbon one can not only obtain all static properties that can be obtained from nickel, chrome-nickel, or silico-manganese alloys, but in addition obtain dynamic or antifatigue qualities far in excess of those displayed by any other alloys. A concrete example in confirmation of this will be given later.

From a wide experience with all types of alloys, it is my opinion that where a better material than the best nickel steel is needed, and especially when dynamic excellence is sought, the appropriate types of vanadium-chrome steels may be unreservedly commended. They forge well and machine more readily than chrome-nickels of corresponding carbon percentages.

Chrome-nickel steels are usually made in a high- and a low-carbon type. The former is used for oil-hardened gears and springs and the latter for general structural purposes, such as axles, shafts, forged parts and for case-hardened gears. The high-carbon type carries about one-half per cent of carbon and the low-carbon alloy one-quarter of one per cent; the nickel as supplied by various makers varies from two to three and a half per cent, while chromium from one to one and a half per cent is usual. A nickel-chrome-tungsten steel is sometimes used for springs.

In general, nickel-chrome steels possess excellent static qualities but the difficulties in heat-treatment, forging, and machining lead one to prefer the other type of alloys previously mentioned. Equally good physical characteristics can be obtained more cheaply in first cost and in shop costs from nickel or chrome vanadium alloys. We shall speak further of the relative merits of these steels for oil-hardened gears and springs later.

Silico-manganese and silico-chrome in medium carbons have had considerable popularity abroad for springs and for gears. They also are made in low carbons. Their relatively low cost favors their use, but their feeble resistance to shock and sensitiveness to heat-treatment limits their use. When handled with great care they give good results in works well equipped for obtaining accurate results in their heating operations.

Chrome steels in high carbons are much used for balls and ball races.

Tungsten steels of special analysis are universally used for making magneto magnets. All statements and opinions to the contrary notwithstanding the magnet steel now made at two works in this country is rarely equaled in quality and never equaled in uniformity by foreign products. If foreign magnetos are superior to domestic ones it is because of their mechanical construction and not because they possess, in general, better magnets. The writer feels very deeply upon this subject and has probably made the most exhaustive experiments ever made upon the manufacture and properties of permanent magnet steel.

Having briefly described the type of alloys in general use we beg to submit some observations upon heat-treatments, upon the merits of case-hardened vs. oil-hardened gears; drop-forged gears vs. gears cut from the bar, and, in conclusion, a few words on springs.

Heat-treatment.—The best alloys are none too good for automobile construction; when one has secured the best the market affords, the first step only has been taken to produce good parts. Next come the forging and machining and the heat-treatment, for better or worse. It is money wasted to buy good alloys unless one is willing to study them sufficiently to know how to treat them, and then to supply adequate facilities for so doing.

It is not to be expected that small users will install complete testing laboratories, but a few dollars invested in having occasional tests made will be well spent. There are, however, many large concerns that could and should spend, say $5,000, for which it is believed the whole or a large part of the following equipment could be obtained: The ordinary tensile machine, a microscope, electrical or gas furnaces capable of fine regulation, a good pyrometer, preferably recording. The tensile machine can also be used for making Brinnell hardness tests, spring deflection tests, etc. In addition to these some form of drop-testing machine, such as the Fremont, will be found valuable; a vibratory or repetitive impact test is nowadays considered a necessity, while cold bending and torsion apparatus is useful. This equipment will be of small use, unless a thoroughly good man is put in charge—a careful, conscientious man of sound judgment. This man should direct the heating operations in the factory; he should construct furnaces which heat uniformly, and he should exercise eternal vigilance in keeping the pyrometer installations up to par.

The pyrometer is too often supposed to take care of itself. Too frequently it is never questioned, never calibrated. The best pyrometer of the thermocouple type should be looked over at stated intervals, especially if in constant use. Protecting tubes should be frequently examined and renewed, and electrical contacts looked over. Occasionally check up the millivoltmeter. Unfortunately there are many pyrometers of the thermocouple type on the market which cannot be watched too closely.

If you are going to have pyrometers, by all means see that you have good ones and then see that they are systematically tested. Many people buy high-priced alloy steels and get no better results from them than could be had from a carbon steel properly handled. If you cannot afford a good pyrometer stick to the trained eye of a skilled man; and if you have a good pyrometer employ a skilled man anyway, and consider the pyrometer as an aid. With it you can at least give orders in temperatures rather than in heat colors, and the laboratory and works can meet on an intelligent basis.

Heat-treatment operations depend upon a solid scientific basis. By this we do not mean that steel essentially of inferior quality should be made to pass muster by heat-treatment. On the other hand, however, it might be said that alloy steel in its so-called natural state, as it comes from the rolls, hammer, or drop-forge, is almost unfit for automobile construction. Steel which depends upon alloys for a high elastic limit in its natural condition will have much less elongation than the same steel oil-tempered and annealed. For example, a chrome steel gave in its rolled condition 158,000 pounds elastic limit and 5 per cent elongation, with 9.4 per cent reduction of area. The same steel oil-tempered and annealed gave 153,000 pounds elastic limit, 14 per cent elongation, and 52 per cent reduction of area. In other words, the material was transformed from brittle to tough, from treacherous to safe, without materially affecting its elastic limit. A nickel steel similarly treated had its elastic limit raised 20 per cent with the reduction of area improved and its elongation unchanged.

(To be continued.)

THE AUER GAS RADIATOR.

THE Auer Company has devised a gas radiator in which the principles of the incandescent gas mantle are applied to heating. In the incandescent gas burner a mixture of air and gas is burned with a blue flame, and heats to incandescence a fine network of oxides of the rare earths, consisting of oxide of thorium mixed with 1 per cent or less of oxide of cerium, a proportion which gives the maximum luminous effect. The same principles have been employed in the heating radiator, but a different mixture, in which oxide of cerium predominates, is employed, the ingredients and proportions having been chosen with a view of obtaining the maximum heat emission. Each radiator contains from four to six independent vertical burners, which produce a better effect than the horizontal burners hitherto employed in gas radiators, as they avoid the friction produced in a horizontal burner by the natural tendency of the gas to rise. Hence the new radiator works well with a very low pressure, 4/5 inch or even 3/5 inch—in a word, with any pressure suitable for an incandescent gas light.

Each burner is surmounted by an incandescent mantle. These mantles have not the fragility of the lighting mantles, as they are coarser, and their foundation, which carries the oxide of cerium, is composed of substances of a strength which allows them to be handled carelessly and even dropped on the floor without injury. They are sent everywhere without being strengthened by collodion, which is necessary in the case of lighting mantles. In normal use they are practically unbreakable. The radiator is provided with an escape pipe for the products of combustion. The combustion being absolutely complete, no carbon monoxide is formed, and hence the heater is sanitary. The high calorific power of the mantle and the perfect combustion make the apparatus very economical and very effective in proportion to its size. The radiation is much more intense than that of the pieces of refractory earth or the masses of asbestos which are commonly employed in gas radiators.

Finally, the small mass of the mantles causes them to become heated instantaneously, whereas clay radiators occupy from one-quarter to one-half hour in heating. This property is very valuable in an apparatus for rapid and intermittent heating.

Another interesting improvement is introduced, by which the production of heat may be varied within wide limits. The connections are such that by the turning of a single four-way cock two, four, or six of the burners may be lighted or all extinguished. The burners which remain lighted operate in a normal manner. This arrangement is far better than the method of diminishing the supply of gas to all the burners at once. In the latter case the pressure of the gas is reduced, the conditions of combustion are changed, and poisonous products, smoke, and unpleasant odors are produced. The frame which carries the burners is so mounted that it can be moved easily outside of the apparatus. The object of this is to make it possible to remove at frequent intervals the incrustation caused by atmospheric dust, which in time clogs the tubes and nettings of the burners.

An electric anemometer on a somewhat novel principle is devised by a German inventor, M. Goldschmidt. It is based on the principle of placing a wire carrying an electric current in a draft of air. Such a wire will be heated by the current, but on the other hand it will be cooled by the air current, and the cooling effect will depend on the rate at which the air is flowing. Thus the temperature of the wire will depend on the air current, and consequently the electric resistance of the wire will vary with the rate of flow. A standard wire carrying the same current but kept inclosed from the air, is used for comparison. The two wires are connected on the plan of the Wheatstone bridge in order to compare the resistances, and we use the difference in resistance between the two wires in order to estimate the rate of air flow.

AUTOMATIC FEEDERS.*

DEVICES FOR HANDLING MATERIAL IN BULK.

BY C. KEMBLE BALDWIN, CHICAGO, ILL., MEMBER OF THE SOCIETY.

CAREFUL study of this subject reveals the fact, so common in engineering, that a particular type of feeder has been developed in a certain industry, or locality, and is little used elsewhere. The types illustrated and described here are only those which have come under the writer's personal observation in many processes and locations within the past fifteen years. There may, therefore, be many other types.

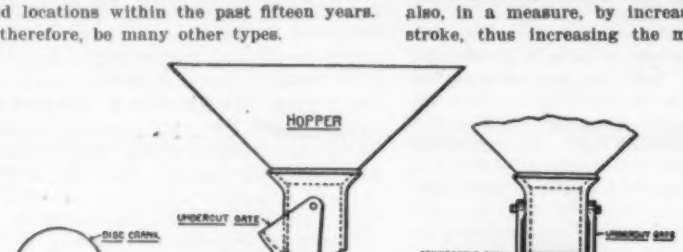


FIG. 1.—UNDERCUT-GATE FEEDER.

When handling dry, free-flowing material such as grain, from a storage bin to a conveyer, a feeder is not required, as a simple gate may be set to give the desired opening, thus allowing the proper quantity to flow from the bin. Should the material be of varying size, such as mine-run coal, a simple gate is not satisfactory unless constantly attended. Even then it is impossible to get the same constant, regular feed that a properly designed feeder gives. If the gate is raised high enough to allow a large lump to pass, there usually results a rush of fine material, which floods the conveyer before the gate can be closed. The automatic feeder, therefore, not only saves the expense of an attendant, but insures a constant and regular feed, irrespective of the size of the material.

Fig. 1 shows the undercut-gate feeder, with a body either of cast iron or steel plate. Pivoted near the top is the undercut gate—which is swung back and forth by a connecting rod from crank or eccentric. This type of feeder is best adapted to fine-sized, free-flowing material. Material containing lumps is likely to bridge. As the feed is intermittent, the feeder is generally used in connection with chain or bucket conveyers, the strokes being timed to feed material between the flights, or into the buckets. The capacity may be changed only by changing the length or the number of strokes. As the length of stroke is more easily changed, it is preferable to use a crank rather than an eccentric, as in practice the quick return of the eccentric has not been found of sufficient value to offset the great advantage of a crank with an adjustable throw.

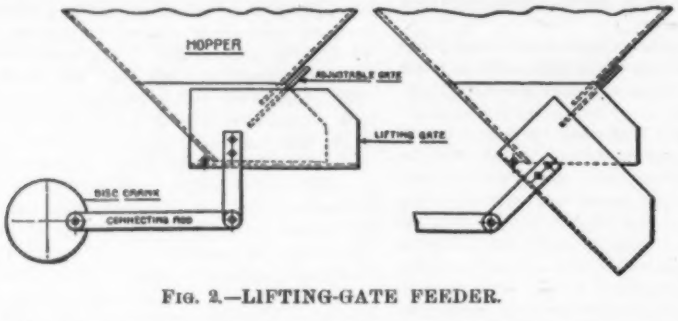


FIG. 2.—LIFTING-GATE FEEDER.

The lifting-gate feeder, shown in Fig. 2, also gives an intermittent feed and is therefore used only with a chain or bucket conveyer. The chute is hinged so that when down, the material will flow out of the hopper, but when raised above the angle of flow of the material, the discharge is stopped. The moving of the chute may be accomplished by a connecting rod receiving motion from either crank or eccentric. This feeder will handle material regardless of size, but it must be free-flowing material, so that it will move by gravity when the chute is lowered to the angle of flow. The capacity may be adjusted by varying the number of strokes, also, in a measure, by increasing the length of the stroke, thus increasing the maximum angle of the chute and causing the material to flow more quickly.

The screw-conveyer feeder, illustrated in Fig. 3, will deliver a constant stream of material, but in this case also it must be of such a nature that it will flow by gravity to the screw. The capacity can be changed only by altering the speed of the screw shaft. This type of feeder has a large field in the handling of pulverized material, such as coal, cement, etc.

The roll feeder, shown in Fig. 4, is extensively used in the mineral industries for handling both large and small materials. The roll is so located under the hopper that the material will not flow when the roll is stationary, but when rotated it will carry the material forward. The capacity is determined by the speed and width of the roll, and the thickness of the stream, as fixed by the adjustable gate.

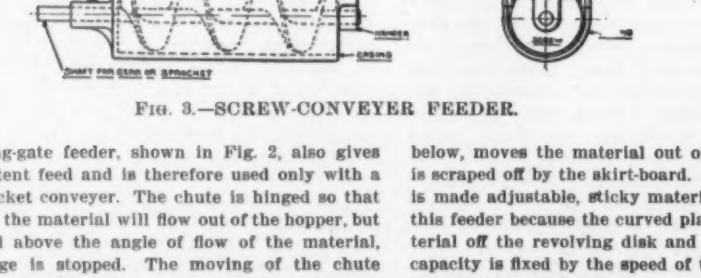


FIG. 3.—SCREW-CONVEYER FEEDER.

The roll feeder has been successfully used in handling iron-ore, coke, and stone from the bins to the weigh cars for furnace changing. Edison used this type for feeding ore and stone from bins to crushing-rolls. The disadvantage is the head-room required, owing to the large roll necessary to satisfactory operation. For handling mine-run material, the roll should be 6 feet to 8 feet in diameter and in many cases it is not possible to obtain this space.

The rotary-paddle feeder, Fig. 5, acts not only as a feeder, but as a measuring device. It is used for fine material which flows readily from the blades. The capacity is fixed by the speed of the paddle shaft.

The revolving-plate feeder, shown in Fig. 6, is used mostly for feeding stamp-mills. The inclined plate driven by gears, placed either above (as shown) or below, moves the material out of the hopper where it is scraped off by the skirt-board. When the skirt-board is made adjustable, sticky material may be handled by this feeder because the curved plate will scrape the material off the revolving disk and into the chute. The capacity is fixed by the speed of the plate and the location of the adjustable gate.

Fig. 7 illustrates the apron-conveyer feeder used for handling material of all sizes. The conveyer may be of any of the various types of apron flights, depending on the nature of the material handled. The chain should be provided with rollers or wheels traveling on track to prevent the apron from sagging. The capacity is fixed by the speed of the apron and the position of the adjustable gate.

The disadvantage of this type is the inherent disadvantage of the apron conveyer. Should the flights become bent or buckled, the material leaks through or catches between them. It has an advantage over other feeders in that it may be used to carry the material a greater distance.

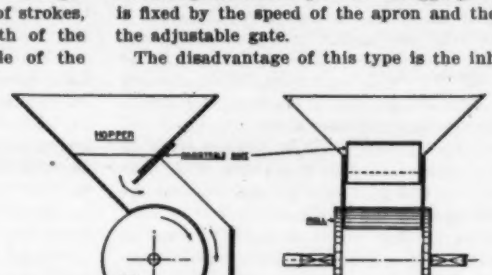


FIG. 4.—ROLL FEEDER.

A rubber or canvas belt may be used in place of the apron, in which case the belt is supported by idlers placed close together.

The swinging-plate feeder, shown in Fig. 8, is used for handling coal and such material of all sizes. It consists of two castings pivoted at their tops and swung alternately so as to move the material forward on the bottom plate. The plates are moved by connecting-rods from a crank or eccentric through a rocker shaft. The capacity is fixed by the length and the number of strokes, but as it is limited to the amount of material displaced by the plates, a wide range is not possible.

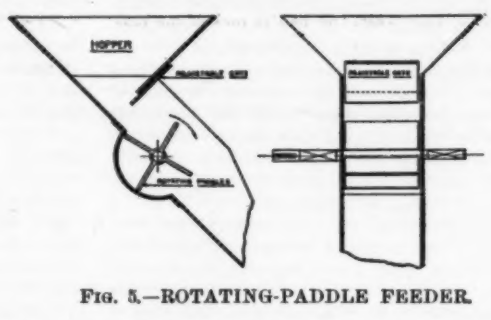


FIG. 5.—ROTATING-PADDLE FEEDER.

The disadvantages are the lack of adjustability and the tendency of the material to pack. It will also be noted that the feeder is not self-cleaning, so that the bottom plate always contains material which is very liable to freeze in winter.

The plunger feeder, illustrated in Fig. 9, is similar in operation to the swinging-plate feeder in pushing the material along the bottom plate. The plunger may be built either in one or two parts, moving ahead alternately and driven through a rocker shaft, as in the case of the one previously described. The capacity is fixed by the number and length of the strokes and the location of the adjusting gate. This type has the same disadvantages as the swinging plate feeder, the most serious of these being that it is not self-cleaning.

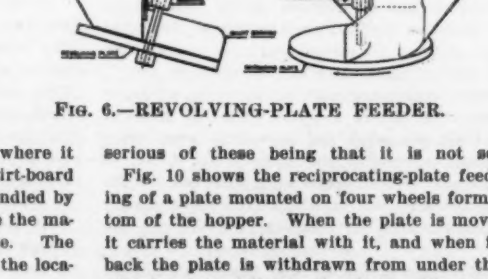


FIG. 6.—REVOLVING-PLATE FEEDER.

Fig. 10 shows the reciprocating-plate feeder, consisting of a plate mounted on four wheels forming the bottom of the hopper. When the plate is moved forward, it carries the material with it, and when it is moved back the plate is withdrawn from under the material, allowing it to fall into the chute. The plate is moved by a connecting rod from crank or eccentric. The ca-

* Presented at the Washington meeting of the American Society of Mechanical Engineers.

pacity is determined by the length and number of strokes and the location of the gate. The disadvantages are the lack of adjustment and the inability to clear the feeder of material.

The shaking feeder, Fig. 11, consists of the shaker-pan located under the opening in the bottom of the hopper at such an angle that the material will not flow when the pan is stationary. When given a reciprocating motion by the crank and connecting-rod, the material is moved forward on the pan. The front end of the pan is carried by a pair of flanged wheels; the back end is suspended by two hanger-rods, each being

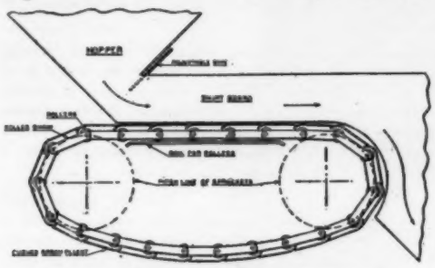


FIG. 7.—APRON-CONVEYER FEEDER.

provided with a turnbuckle so that the angle of the pan may be varied. The crank having an adjustable length of stroke, there are three variables, viz., number of strokes, length of stroke, and inclination of the pan. As the number of strokes is difficult to change, and the others easily changed, the feeders are usually designed for about 75 strokes per minute, a number determined by experiment. The angle of the pan is fixed by the capacity desired and the nature of the material handled. For coal, stone, ore, etc., 8 deg. to 10 deg. is sufficient, while clay and other sticky substances require from 15 deg. to 20 deg. The length of stroke varies from 4 inches to 12 inches, so that a large range is possible.

A feeder designed to handle 400 tons per hour of mine-run coal was changed in five minutes to deliver 30 tons per hour by shortening the length of stroke and lowering the pan until nearly horizontal.

Not only has this feeder the widest possible range in capacity, but it is self-cleaning, a very important feature. From the cut it will be noted that the pan is placed under the opening and the material rests directly on the pan, so that when the pan is moved the material in the hopper is moved, which prevents the material from bridging.

The shaking feeder has none of the disadvantages of the other types for general use, and possesses many advantages which the others lack. Owing to its great flexibility it is more easily standardized and will successfully handle practically any material, regardless of size or condition. If desired the bottom plate may be perforated to screen out the fine material, thus acting as both screen and feeder. This is not possible with any of the other types.

The power required by all of the types is so small that it is not an important consideration. The shaking feeder mentioned above, which handled 400 tons of coal per hour, required but 3.5 horse-power.

The preceding cuts and descriptions will give a general idea of the different types and their possible uses, so that an engineer may readily choose the best type for the work to be done. The point that should be kept in mind is, that it is always advisable to gear the feeder to the conveyer, crusher, or other machine which it feeds so that they will both start and stop simultaneously.

ELECTRICITY AS A FUEL.

TO SPEAK of electricity as a fuel may appear misleading, yet to speak of it as a substitute for coke would be little more accurate. It has already been

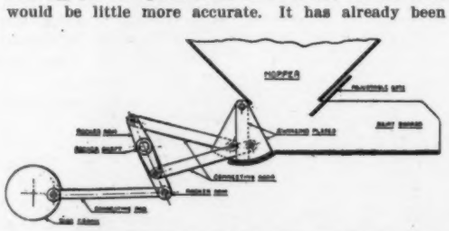


FIG. 8.—SWINGING-PLATE FEEDER.

employed tentatively yet with success in this way, and very important and far-reaching developments are in sight. To make what we have to say clear from the outset it is necessary to recall to our readers' minds the fact that electric furnaces have long been in use for the reduction of refractory ores. Thus, electricity has made aluminium cheap enough to permit it to be employed for such domestic utensils as pots, kettles, and saucepans. In these cases, however, an enormously high temperature is sought for; and the furnaces are, by comparison with, say, those used for making open-hearth steel, tiny affairs. Recently attempts have been made to reduce iron ore by the aid of electricity, and more than one electric "blast" furnace is now in existence in America. Ore exists in certain regions a long way from coal. The conditions are just those of our own hematite districts into which coal has to be taken. By the aid of electricity two-thirds of the normal quantity of coke can, it is said, be saved, and inasmuch as current generated by water power at a very small cost can be transmitted over long distances, it would seem that a new and valuable industrial system only awaits development.

Extended reference was made to the electric furnace at the recent meeting of the Iron and Steel Institute, and the principal topic of discussion during the May meeting of the American Electro Chemical Society was the proposed method of making iron and steel practically on the Heroult system, which has already been noticed in our columns. The principle involved was set forth by Prof. J. W. Richards. The amount of fuel used in a blast furnace is determined by the quantity that must be burned in the tuyere zone to produce the necessary smelting temperature, and not by the quantity required to reduce the metallic oxides. This latter varies between one-third and one-half of the amount required to produce the smelting heat. But in the electric furnace all the heat is supplied by the electric energy and carbon is only required for the chemical reactions. If too much carbon is introduced there will be trouble owing to its accumulation; but this can be avoided by blowing in a little air to burn it. It is claimed that with charcoal from one-half to four-fifths may be saved. Reducing generalities to figures, we may write that only one-quarter of the heating power of the fuel is developed around the blast tuyeres, and that if half of this could be replaced by electrically generated heat, an economy of 50 per cent could in all probability be reached upon the fuel bill. It takes 1.2 tons of coke to make a ton of pig iron in the normal American blast furnace, and about ¾ ton is burnt by the blast, producing at the smelting zone about 25 per cent of the calorific power of the coke. If electrical energy could be made to supply only one-half of this, the furnace would make iron with half the previous coke

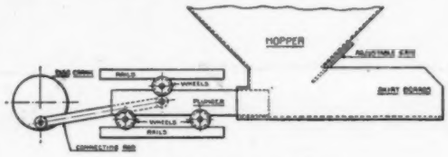


FIG. 9.—PLUNGER FEEDER.

supply, that is, with 0.6 ton of coke per ton of pig iron, and this with an expenditure of electrical energy equal only to 12.5 per cent of the calorific power of the coke, that is, equal to the calorific power of but 0.15 ton of coke.

This calculation, it will be seen, takes no account of the transmission of electric energy. The advocates of the new system speak of it as a direct means of reducing the cost of pig iron under all conditions of situation and environment. But the conditions to which we have already referred appear to us to be in certain respects more important by far. One of the speakers dealt with the situation in California, and showed that while there was a considerable demand for pig iron there was no fuel with which to make it, save at a prohibitory price. The only plentiful fuel is California asphaltic petroleum, which cannot be used for the purpose. Metallurgical coke brought from the East by rail would be out of the question, while imported coke is not only high in price but irregular as to supply, and, therefore, variable in price. The California demand for coke is met by importation from Germany, Belgium, and Australia. The coke is bid for upon arrival, hence the irregularity both as to price and supply. The price may be anywhere between $10 and $13 per ton. Therefore a blast furnace plant would be an investment of uncertain value. But with water power, electricity, and charcoal as fuel all the conditions would be changed. The question is being tested on an adequate scale by the Noble Electric Steel Company, which has built a small town and called it Heroult, on the Pitt River. The company has acquired the Shasta ore mines, and constructed a charcoal-making by-product plant with all the most recent improvements. Current is supplied by the Northern California Power Company. The first furnace was started in July, 1907, and failed. Further experiments were then made, and success seems to have been attained. We have no sectional drawings of the furnace, but from the description it appears to be a small blast furnace of the usual type, fitted with a double bell and hopper. The place of tuyeres is taken by six electrodes arranged equidistantly around the furnace. The electric current passing between them melts the charge, and the molten metal and slag are collected in the crucible, from which they are tapped as in ordinary blast furnace work. Three tap holes are arranged at different levels, so that the crucible may be partially or completely emptied as desired. The tap holes are provided with bronze water-cooled casings. There are two or three other systems of working, devised by Kjellin, Colby, and Roechling and Rodenhauser. Then there is a second Heroult, in which one of the electrodes is a massive block of carbon in the hearth bottom. It is not unnaturally claimed that charcoal pig iron made in this way ought to be of a very high quality.

The process is as yet in its infancy, and it may be said that it is quite too soon to speak of it as a commercial success. Failures and troubles are no

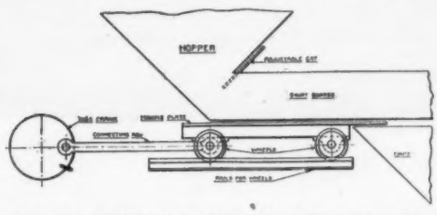


FIG. 10.—RECIPROCATING-PLATE FEEDER.

doubt to be expected; but the whole metallurgical history of the world is a continuous record of struggles and ultimate success. The Bessemer process is a pertinent case in point. If ore can be reduced on a large scale in this way it is obvious that an enormous saving in the cost of plant ought to be effected. Thus, for example, Cowper stoves would no longer be required. The plant for handling materials would be diminished in size. The blast engine would disappear. The furnace would be put up at the ore mine, and little consideration would be given to the transport of coke. To say that the electric smelting furnace will revolutionize the manufacture of pig iron would be to go too far. Yet, with active, clever men, plenty of money, skilled metallurgical chemists, and unlimited supplies of electricity, it would be yet more rash to assert that very great things indeed cannot be accomplished. It is worth noting that, during the discussions which followed the reading of several papers on the same subject under different aspects, no one raised a doubt as to the attainment of ultimate success. If this is secured, then we shall have the cost of fuel consumed in the production of pig iron reduced by at least one-half. That of electricity ought to be small. Concerning this point, however, there is as yet very little information in existence. But most important probably at all events for several years to come, would be the part played by electricity in developing the production of iron in some of our own colonies and dependencies, where it is impossible to bring ore and fuel together save at prohibitive prices. As we have said, all the conditions would be altered if electricity could be produced by water power at a very low price and transmitted to the ore district. Of one thing we may rest assured, namely, that the iron and steel makers of the United States are not the men to let the electric "blast" furnace sink into oblivion without giving it as complete a trial as unlimited money can command.—Engineer.

The employment of photograph films wound on reels, for moving pictures and some others, has confronted photographers with a new difficulty. The ribbon of celluloid becomes electrified by contact with the gelatine coating of the next turn, or with the interposed

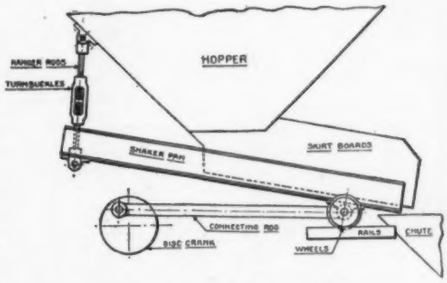


FIG. 11.—SHAKING FEEDER.

strip of black paper. Sometimes electric discharges occur which produce zigzag or arborescent lines in the developed film. This accident is most likely to occur in a warm and dry atmosphere, and especially on removing the reel from the camera. The film is often slightly uncoiled and the operator tightens it by a twist which produces friction between consecutive turns of the ribbon. Fortunately the makers of films have discovered a remedy, which consists in coating the back of the celluloid with gelatin.

ENGINEERING NOTES.

The most simple furnace and the one least suited to burn bituminous coal is the hand-fired grate with a small combustion space bounded principally by iron surfaces. This furnace is found in house boilers and locomotive types. The best furnace for most coals is one which is so designed that the coal is fed regularly in small quantities; air is admitted to the gases which are slowly driven from the coal and combustion takes place in a large combustion chamber which allows the gases to burn before they reach the cold surfaces of the boiler tubes.

Pennsylvania has been losing her pre-eminence as a rail-producing State. Going back to 1897, the statistics show that Pennsylvania mills rolled 1,024,386 gross tons of steel rails, against 590,013 tons, for all other States. By 1901 the total for other States had just passed that of Pennsylvania—1,430,265 tons against 1,406,008 tons. In 1902 the rails rolled by all other States amounted to 1,786,967 tons, while Pennsylvania rolled 1,148,425 tons. But the contracts of 1907 and 1908 are very pronounced, the totals showing in gross tons:

	1908.	1907.
Pennsylvania	493,024	1,130,769
Other States	1,428,587	2,501,960

Taking Bessemer rails alone, the Pennsylvania showing in 1908 is still less consequential, its product being but 315,563 tons out of a total of 1,354,236 tons. The Bethlehem mill will help to maintain the Pennsylvania percentage, now that open-hearth rails are called for in increasing quantities, but the rolling of open-hearth rails at the Ohio and Gary plants of the Steel Corporation, in some cases at the expense of the Edgar Thomson mill, will tend to enlarge the percentage for other States.—Iron Age.

Since the earthquake catastrophe of Messina, the question has come up of the use of reinforced concrete for buildings in order to resist earthquakes, and we may expect good results from it in such cases. The village of Favellani in south Italy was entirely rebuilt in reinforced concrete after the earthquake of 1905, and these as well as several houses in Messina of the same material were found to have escaped the late disaster. An Italian engineer, M. Danusso, finds that reinforced concrete buildings hold together longer and fall but slowly, so that the dwellers have time to escape. The shock produces bending and cracking at first, which gives warning of the disaster. Cellars should not be used, according to the principles he deduces for construction, and a smooth cement surface on the soil is best as a platform for building the structure. One or two stories should be the limit. M. Cesare Pesenti, another Italian engineer, prescribes separating the building completely so as to make it independent of the ground platform, resting on it simply, and this with as small a surface as possible of contact between the building and the platform, so as to allow for displacements and deaden the vibrations.

ELECTRICAL NOTES.

When silicon is heated to 3,450 deg. F., in a tube of carbon, without access of air, by means of the electric furnace, the vapor of silicon attacks the carbon and the wall of the tube is found incrusted, more or less thickly, with a carbide of silicon, to which Bolling, its discoverer, has given the name silundum. The pure silundum is obtained in granular form, by burning in the air the uncombined part of the carbon tube. Silundum is a hard substance, which conducts electricity and is not affected by high temperatures or by cold acids. It will be useful for various purposes, but chiefly for electric heating.

By the Poulsen method conversation has been carried on between wireless telephone exchanges across the whole breadth of Denmark, from Lyngby to Esbjerg, a distance of 170 miles, the voice of the speaker being not only distinct but recognizable. The music of a phonograph played in Berlin was clearly heard, by the same method, at Lyngby, 290 miles distant. Mr. Poulsen, in a lecture in London on April 15th, enabled his auditors, with the aid of telephone receivers, to hear music radiated from a phonograph to a telephone box in the roof of the London Institution, where the lecture was given.

Friedrich has devised a small electric resistance furnace or oven for laboratory use. A tube of iridium, with a total length of 5 inches, and internal diameter of 0.8 inch, a thickness of 0.016 inch, and an effective heating length of 4 inches, is closed at both ends by sheets of heavy platinum foil, backed by plates of pure nickel, to which the current is conducted by bars of copper. Loss of heat is diminished by surrounding the iridium tube with a tube of fire clay. The substance to be fused is placed in an inner tube of 0.6 inch internal diameter, 0.04 to 0.08 inch thickness and 4 inches long. A current of 900 or 1,000 amperes at 3 volts produces a temperature of 1,700 deg. F. in 30 seconds. The iridium tube has the advantage over a carbon tube of becoming heated more rapidly and of leaving the inclosed air uncontaminated.

The Berlin company for the manufacture of storage batteries has issued the following recommendations: 1. Storage batteries should be installed in rooms used for no other purpose, near the engine and dynamo rooms, easily ventilated and not exposed to great variations of temperature. 2. The rooms should be guarded from the entrance of dust, vapors, and gases, and from violent shocks and vibrations. 3. They should contain no iron columns or metallic pipes. If pipes or columns are indispensable, they should be protected by acid-proof varnish. 4. The illumination should be furnished by incandescent electric lamps. 5. When the batteries are in use the rooms should not be heated, except in extremely cold weather. On the other hand, rooms containing batteries which remain idle for a long period should be kept moderately warm. 6. The foundations or supports of heavy stationary batteries should be constructed with great care. Rough plastered ceilings are liable to crumble and fall, and should be avoided. 7. The room should be thoroughly ventilated when the batteries become exhausted, at which time a great deal of gas is evolved. Roof ventilators with Venetian blinds should be avoided, as they admit dust which may fall on the batteries and cause short circuits.

JUST PUBLISHED *JUST PUBLISHED*

A BOOK OF INTEREST TO RIFLEMEN

The Bullet's Flight from Powder to Target

The Internal and External Ballistics of Small Arms.
A Study of Rifle Shooting with the Personal Element Excluded, Disclosing the Cause of the Error at the Target.

Illustrated with one hundred and eighty-eight plates, showing the results of over three hundred rifle experiments performed and chronologically arranged

By F. W. MANN, B.S., M.D.

Size 7½ x 9¾ inches. 384 Pages. Price $4.00 postpaid.

THIS is a thoroughly practical treatise and deals with a subject the literature of which is not commensurate with its importance or interest, and it possesses unusual value, not only because it furnishes a large amount of information, of a very practical kind, but because this information is the result of a practical experience on the part of the writer, extending over a period of thirty-eight years. The results of the author's experiments, as here given, have been persistently and laboriously worked out with earnest desire to assist his fellow marksmen. In view of the fact that conjecturing and theorizing have been so prevalent in rifle literature, the work has been kept free from speculation, except where they have either been proved to be false or have been fully substantiated by recorded experiments. Most of the illustrations are photographic reproductions of the results of actual tests. Every page is full of interest for the rifle enthusiast. There is a full discussion of various kinds of rifles, of the effect of difference of length, of variations of rifling, etc., as well as of instructive experiments such as that of venting the barrel near the muzzle. An idea of the contents may be gathered from a few of the subjects treated, such as the Personal Element vs. Mechanical Rifle Shooting; Utility of Vented Barrels; High-Pressure Sharpshooting Powder; Telescope Mounts; Ruined Rifle Bores vs. Smokeless Powder vs. Primers; Accurate Ammunition Difficulties; Flight of Bullets; Gyration and Oscillation; Motions Executed by Normal Flying Bullets; Determining Rifle Twists; Kinetics of Spin, etc. In many respects this work is unique in the literature that has been published on this subject. It is a thoroughly practical work and will be found to be of very real value to those who are engaged in a study of the ballistics of the rifle with a view of improving the all-around efficiency of that weapon.

MUNN & COMPANY, Publishers, 361 Broadway, New York City.

TRADE NOTES AND FORMULÆ.

Washing Fluid for Straw Hats.—This consists of two separate fluids one of which is used 24 hours after the other. I. 100 parts of hyposulphite of soda, 750 parts of water, 50 parts of glycerine, 100 parts alcohol. II. 20 parts tartaric acid, 900 parts water, 100 parts spirits.

Vienna Laundry Gloss.—100 parts of white, strong-lathering soap are cut in pieces, dissolved in 500 parts of water, and after cooling, 10 parts each of permanent white (baryta white), feather white (fibrous gypsum), and the whites of two eggs, beaten to a foam, are added. The mixture will keep for quite a long time in tightly-closed porcelain jars.

Acid-Proof Coating.—Mix a strongly concentrated solution of 20 parts of water glass with 10 parts of heavy spar and 20 parts of finely pulverized asbestos. The specific gravity of the water-glass solution must range between 30 deg. and 40 deg. Bé. We thus obtain a dough-like mass that speedily hardens and can be applied to all vessels used to contain strong acids, as it will withstand even concentrated sulphuric and fuming nitric acids.

Xylonite, or fibrolithoid, is a variety of celluloid. It is produced in fluid form by dissolving: I. 40 parts of nitrocellulose in 20 parts of cedarwood oil and 40 parts of acetate of amyl. Serves as a dipping varnish for metals. II. 10 parts nitrocellulose, 30 parts acetate of amyl, 25 parts of amyl alcohol, 2 parts cedarwood oil, 3 parts benzine. If the product is to be obtained in solid form, it is concentrated by evaporation.

Manufacture of Water Glass.—According to Propfe's German patent, the employment of sulphate is avoided, because it contains iron. Sand, chlorate of potash, and carbon are ground, then the necessary quantity of sulphuric acid is added, and it is gradually heated to 400 deg. F., the hydrochloric acid being thereby completely expelled. The calcined mass can be readily melted. If no rock salt, only saturated brine, is available, it should be absorbed by sawdust or peat, which must be dried in the sun, mixed with sand and treated as above.

Non-sulphurous Igniting Mass.—According to a German patented process, 25 parts of adhesive substance (gum, dextrine, etc.), 60 parts chlorate of potash, 5 parts of a metallic resinate or sebate (palmatinate of manganese), 8 parts of a neutral fatty substance, which, according to the color of the igniting tips desired, may consist of zinc white, iron oxide, ultramarine, etc., 2 parts of chromate of potash, with the necessary quantity of water, is made up, by the customary methods, into an igniting mass suitable for dipping. The latter, in finely ground condition, is dipped on to the paraffined match sticks, thereby insuring that this igniting mass can be caused to ignite and burn without any offense to the organs of smell or respiration.

Ink for marking cases is prepared by dissolving 10 parts of extract of logwood in 500 parts of water, adding two parts of yellow chromate of potassium. The formation of a sediment does no harm, it is only necessary to stir it up with the marking brush. When necessary, water may be added. Another ink is obtained by dissolving some gum damar in oil of turpentine, which is quickly effected by the application of a little heat. In this weak varnish, a black color is stirred, which must be very finely ground. After use, the oil of turpentine is volatilized and the gum secures the color to the wood. This marking ink should be kept in well-closed bottles, and will then remain good for years. If the color has become too thick, it can be reduced with oil of turpentine.

TABLE OF CONTENTS.

PAGE

I. AGRICULTURE.—The Consumption of Nitrate of Soda in the United States.—By CHARLES E. MONROE..... 407

II. AUTOMOBILES.—Alloy Steels for Motor Car Construction.—By JOHN A. MATHEWS, Ph.D., Sc.D..... 410

III. ELECTRICITY.—Electricity as a Fuel..... 413
Electrical Notes..... 414

IV. ENGINEERING.—The Relation of the Character of Coals to the Prevention of Smoke.—By D. T. RANDALL..... 402
Automatic Feeders for Handling Material in Bulk.—By C. KEMBLE BALDWIN..... 412
Engineering Notes..... 414

V. MISCELLANEOUS.—The Tyranny of Scientific Dogma..... 403

VI. NAVAL ARCHITECTURE.—The New North German Lloyd Steamer "George Washington."—8 illustrations..... 408

VII. OPTICS.—The Auer Gas Radiator..... 411

VIII. PHOTOGRAPHY.—Photographs in Natural Colors..... 409

IX. TECHNOLOGY.—Vegetable Parchment..... 403
Trade Notes and Formulæ..... 414

X. ZOOLOGY.—The Ant and Her Ways.—By Prof. K. ESCHERICH.—24 illustrations..... 406

6122